ENGINEERING

An Illustrated Weekly Journal

35 & 36 BEDFORD STREET, STRAND, LONDON, W.C.2 TELEPHONE: TEMPLE BAR 1662

Vol. 178 No. 4631 LONDON, FRIDAY, OCTOBER 29, 1954 Price 2s.

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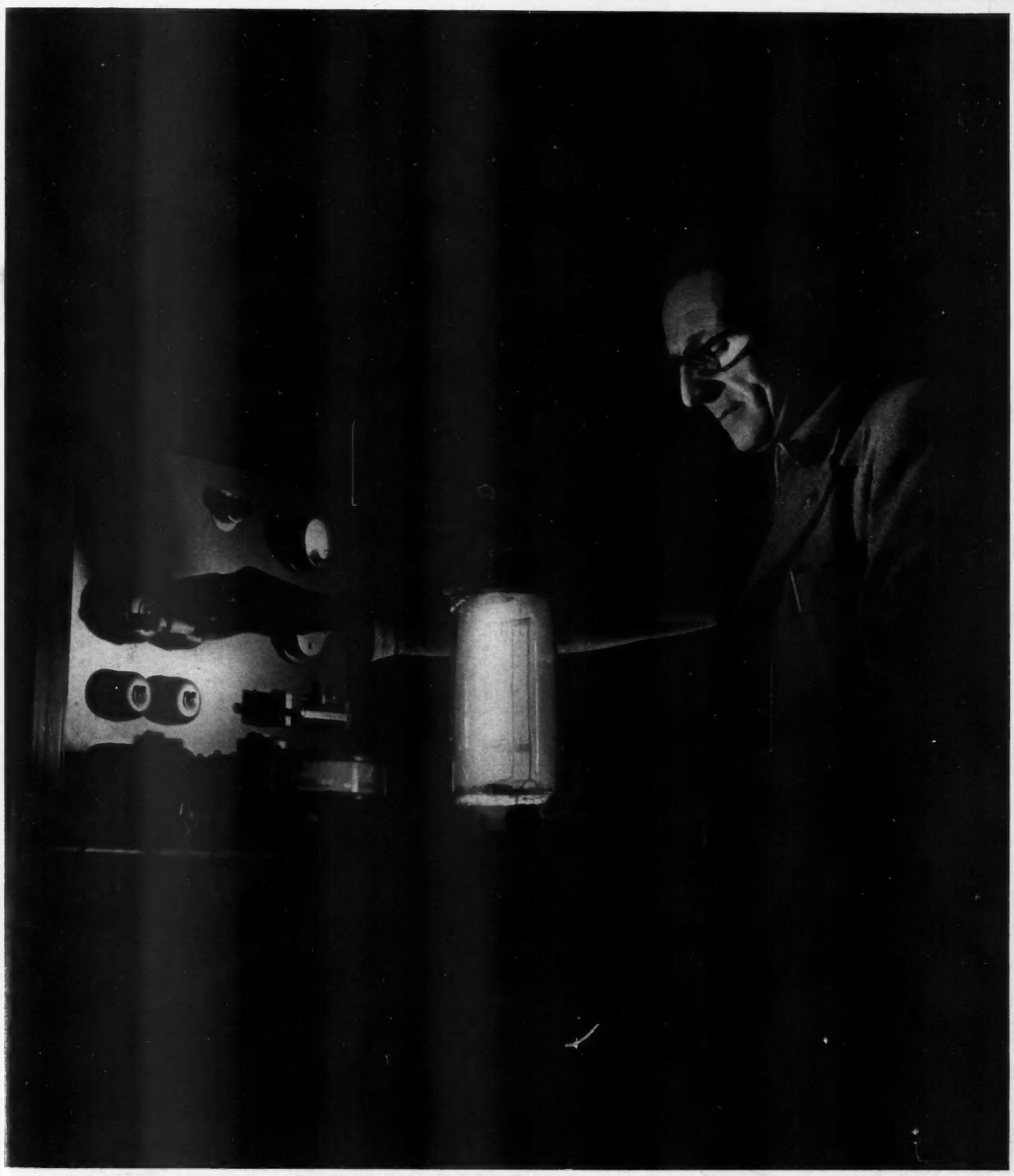

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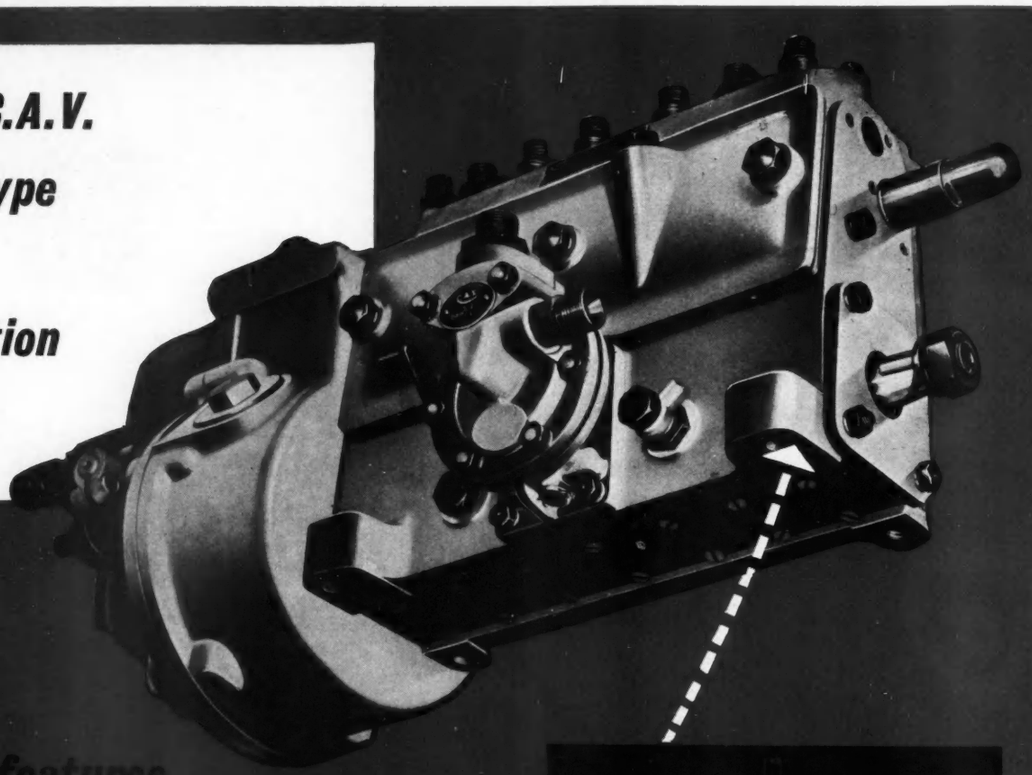

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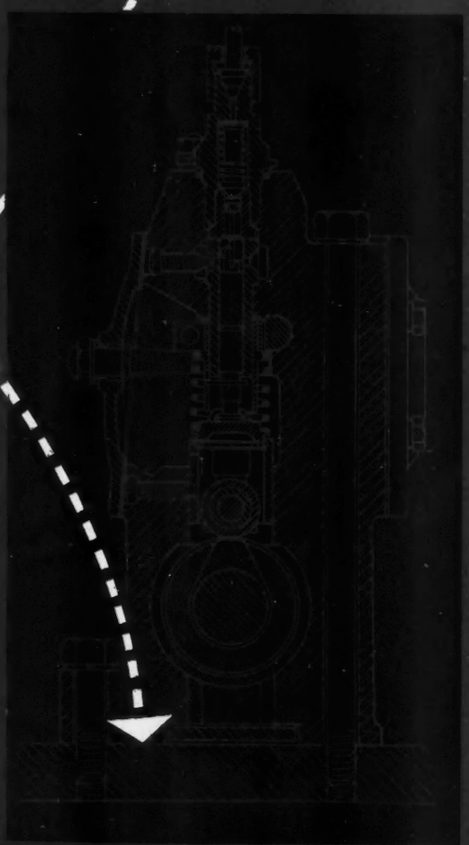

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Published every Friday by Engineering Limited 35 & 36 Bedford Street, Strand, London, W.C.2 TELEGRAPHIC ADDRESS *Engineering, Lesquare, London* TELEPHONE *Temple Bar* 3663

Subscription Rates for 12 months, Inland and Abroad £5 10s., Canada £5 5s. Subscriptions for periods of less than 12 months are based on the price of a single copy including postage [2*s.* 3*d.*]

MOTOR CARS

THIS year the British motor industry expects to achieve a total output of over one million cars and commercial vehicles in twelve months, for the first time ever. Despite strong and well organised competition, Britain is still by far the world's largest exporter of motor vehicles and our biggest foreign-currency earner among the manufacturing industries. The motor-vehicle manufacturers are very large customers of the primary producers, and the prosperity of the industry has a very important bearing on the general level of trade in the country. Provisional export figures for the first nine months of this year show that over 282,000 cars were exported, with an aggregate value of nearly £91½ million. This is admirable, but seasonal transport difficulties, a dock strike, or the sudden imposition of economic restrictions, such as those Canada and Australia have been obliged to introduce in recent years, could jeopardise employment in the industry if there were no healthy home market to absorb the surplus. Yet the home buyer is so harassed by taxes and high repair costs, by threats and exhortations and high accident rates, and by the difficulty of finding anywhere to park the car that it is increasingly difficult to understand how the demand is maintained. This is not a healthy situation.

The industry is now spending well over £100 million to improve its equipment and expand its production facilities; and users of its products pay over a million pounds a day in special taxes, but the Government still has no adequate plan for developing a modern road system which will enable the vehicles to be employed efficiently.

It appears as though British Government policy is to maintain a very high rate of vehicle taxation; not to pay for new roads, or even to release vehicles for export, but simply to discourage their use at home. Figures collected by the British Road Federation show that New Zealand is now spending more money on roads than the total vehicle tax revenue, and Australia, our best car customer, is spending 85 per cent. of vehicle tax revenue on roads. Sweden is spending 80 per cent. and will soon reserve vehicle taxes entirely for road works. The United States is spending 70 per cent., and 21 states have constitutional amendments forbidding diversion of road taxes to other uses. France, by allocating 60 per cent., has built 5,000 new bridges since the war, modernised many main highways and is now driving a road tunnel through Mont Blanc. Italy, by allocating 32 per cent., has built 9,900 miles of new roads in the same period. West Germany is embarking on a seven-year programme to construct 370 miles of new autobahnen. In Britain, not one mile of motorway has yet been constructed and Government expenditure on roads is only 10 per cent. of vehicle tax revenue. The creeping paralysis of the road system is a threat to the prosperity of the motor industry and a growing burden on the economy of the whole country.

The structure of the industry itself is changing steadily. Two of its biggest producers are under American control and they are being expanded with plentiful injections of dollars. The implications are not lost upon the others, and Sir Leonard Lord has already referred to these expansion programmes as a means of using Britain as a springboard for an advance into Empire markets. Other members of the industry are responding vigorously to this challenge from within, although as one of them recently remarked, one dare hardly mention any re-equipment scheme costing less than £10 million.

Important economies are being secured by rationalisation, especially by the British Motor Corporation, but there is much scope for further developments, both in vehicle manufacture and in the component industries. Some of the smaller car companies are finding conditions difficult, but there is healthy activity in the construction of sports cars using modified components obtained from the big corporations. This can result in a useful exchange of ideas, leading to improvement of the standard cars rolling off the principal production lines, as is shown in this week's article (the second of three we are publishing). The buyer's interest is stimulated this year by a large number of new and improved cars. Engines have been developed to obtain more power and better consumption figures on high-grade fuels. Five makers now offer cars with fully automatic transmission systems, one of them a new British system on a car selling at a basic price of only £750. Of the cars with conventional transmissions many can now be delivered with an easily engaged overdrive. New dual-purpose vehicles can carry goods during the week and provide comfortable family transport at week-ends. Britain's first full air-conditioning system for cars is on view, with a refrigerator to cool the air in summer. Disc brakes appear for the first time on cars offered for sale to the public and the tubeless tyre raises hopes of eliminating the spare wheel. The motor industry now produces a magnificent range of vehicles to meet practically every need. There are a few gaps, and some apparently needless duplication, but no industry in the world offers such a varied range of well-tried cars, or such excellent all-round value for money.

Weekly Survey

BUOYANT EUROPE

The recovery in Western Europe's prosperity in the last year or so is no longer a question only of statistics. It is now the theme of official statements. Last week Mr. Butler made reference to the possibility of expanding trade between this country and the other members of O.E.E.C., and Mr. Marjolin, the Secretary-General of O.E.E.C., discussed Europe's rapid industrial progress when he addressed the European Management Conference at Torquay. He argued for the need to reduce quantitative restrictions on trade and the abolition of restrictions on American imports. He considered that this last was possible to a certain degree with the present state of Western Europe's balance of payments and he is not alarmed at the prospect of a certain amount of American competition.

Mr. Marjolin went on to warn his audience against the acceptance of a state of stability. It is true that stability in economic affairs must lead in the long run to stagnation, but the likelihood of this occurring is remote. There are plenty of factors at work to maintain a dynamic state in Western Europe's economy. The United States will always exercise some influence on Europe as its economy moves upwards or downwards, no matter how mild these movements may be. Continental Europe is also open to influences at work on members of the British Commonwealth. It is only too clear from the experience of 1951 that sudden changes of trade policy in the Commonwealth can be quickly transmitted through the British balance of payments to the countries in Continental Europe with which the United Kingdom trades. There are also factors at work within Europe itself. Apart altogether from the ebb and flow of political sentiment, which is itself a vital factor, the incorporation of Western Germany in the Atlantic Treaty and the agreement between France and Western Germany on the Saar are bound, when ratified, to have a serious effect on European industry. To take only two consequences, the ability of Germany to make armaments, excluding atomic, chemical and biological weapons, will inevitably have repercussions on the engineering industries of the United Kingdom, Germany, France and Italy.

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HELICOPTER PROGRESS

The importance of the helicopter has in the past no doubt been badly under-rated in the United Kingdom. Recently, however, so much publicity has been given to the strong views of some leading authorities on this subject (and of others who are not authorities) that, although these may be quite justified, there is a danger that public opinion will attach too much importance to one of the very few lines of activity in which the British aircraft industry are not ahead of their competitors. As Lord Balfour of Inchrye pointed out in the recent debate in the House of Lords, it is true that whereas hundreds are flying in the United States there are only 15 civil and 50 military helicopters in the United Kingdom. Lord Brabazon of Tara was sharply critical on several points. He said the export trade in helicopters was worth 5 million dols. a year to United States manufacturers. Some British manufacturers on the other hand had difficulty in obtaining orders. Westland Aircraft, Limited, who had an agreement with the American Sikorsky Company, could not get any orders for the S.56 (26 passengers) although they have had some for the S.55 (10 passengers). The development programmes of British manufacturers, continued Lord Brabazon, were not rapid enough. The Fairey Aviation Company were experimenting with a revolutionary design, but the machine would not be in production until 1960. Although the Bristol Aeroplane Company had produced a twin-rotor helicopter, " not even their best friends could accuse them of being in a hurry."

This is, however, a somewhat extreme statement. Westland Aircraft had reported that many S.55 helicopters, now named " Whirlwinds," are now coming into service and that some will be used for the services from the South Bank to London Airport. The Services have ordered about 100 Bristol 173 twin-rotor helicopters to be used mainly for anti-submarine work. Lord Douglas of Kirtleside, Chairman of British European Airways, has given 1958 as a possible date for the commencement of " bus services " with 45- to 50-seat helicopters, although these will probably be of American design and it will be ten years before a network of helicopter services can be built up throughout the British Isles and to the Continent.

Research and development work on helicopters has been greatly increased in the past few years. Whereas Government grants for this purpose amounted to only £290,000 they will amount to more than £2·5 millions this year, and next year may well be higher still. Government policy is to follow the present development work in gear-driven helicopters with research into reactionless rotor systems. This work should enable the United Kingdom to make up some of the leeway and to make a full contribution to the establishment of world helicopter services. B.E.A. are already participating in the Helicopter Working Group of the International Air Transport Association, along with other major world airlines. The first meeting of the group, which will study the means of promoting world helicopter operations throughout the world, takes place in Montreal on November 11.

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PROSPERITY IN YUGOSLAVIA

The association of Yugoslavia with the West in the past few years has brought economic advantages to that country. These are apparent from *Yugoreport*, a monthly reference periodical published by the Anglo-Yugoslav Commercial Syndicate, Limited. The total volume of Yugoslav seaborne foreign trade has risen, much of it directly due to imports financed directly by aid from the United States, the United Kingdom and France. Foreign aid has also permitted a level of investment which has resulted in greatly increased production in many sectors of the Yugoslav economy.

Output of iron and steel, engineering products, textiles and chemicals have all been rising rapidly. Considerable importance has been attached to raising the output of consumer goods. Output of radio sets in 1954 is running at a level 36 per cent. higher than in 1953 and the output of bicycles is 86 per cent. higher. Under the Draft Social Production Plan for 1955, output of miscellaneous consumer goods, which in 1954 is to be 26 per cent. higher than in 1953, is scheduled to rise by a further 16 per cent. in 1955. Large increases are also planned in capital goods. Output of railway rolling stock is to rise by 25 per cent. and industrial machinery by 25 per cent.

The chemical production programme is perhaps the most ambitious. Sulphuric acid is to rise to 890,550 tons—more than double the 1953 level—while output of superphosphates is to reach 200,000 tons compared with 43,000 tons in 1953. Refined petroleum products will be increased to 864,000 tons compared with 567,000 tons in 1953. Yugoslavia is one of the largest producers of non-ferrous metals in Europe and considerable attention is naturally being paid to developing her resources. Nevertheless, reckless war-time exploitation has made it difficult to increase production. Output of blister copper, for example, which reached a record of 44,000 tons in 1940, now appears to be stabilised at 31,200 tons. Nevertheless, refining capacity has been increased and the whole output of blister copper can now be made into electrolytic.

Much of the Yugoslav output of engineering products will be used at home, but there is already an export market for some. Two hundred and fifty railway tank wagons, for example, are at present being built for Turkey. The Sever Company of Yugoslavia are to set up a factory for making electric motors in Burma, and the Burmese Government have stated their willingness to give Yugoslav engineers a contract for building a copper-wire factory and another for electrical equipment. Shipbuilding activity is at a high level: Government credits totalling 24 billion dinars (at 2 per cent. per annum for 25 years) have been granted to the Yugoslav yards for building ships up to 10,000 tons gross. Most of the tonnage under construction is on home account but Swiss owners have two vessels on order. The booklet thus shows that considerable progress has been made in industrialisation, which will enable Yugoslavia to make an increasing contribution to the Western economy.

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BULK HANDLING OF CEMENT

Recently the Blue Circle Group of Companies, through the medium of the Cement Marketing Company, Limited, brought into commission a new cement depot in London. The depot, which is described elsewhere in this issue, is possibly unique by virtue of several characteristics. For example, the cement is delivered in bulk by barges which bring it from the Group's works located farther down the river; from the barges, it is mechanically unloaded, in all weathers, into the silos; from the silos the cement can be packed in bags or, alternatively, it can be dispatched in bulk in one of the several types of lorry now available for this work.

The advantages to all but the smallest contractors of taking delivery of cement in bulk are considerable, not the least of which is the fact that the cement is about 20 per cent. cheaper, and also that the task and cost of collecting and getting rid of the empty bags is eliminated. Throughout the whole process of distributing the cement the acceptance at site of bulk cement enables actual handling to be almost entirely eliminated with a resultant increase in the cleanliness and health of the workpeople concerned. And finally, it is likely that the cement will go into the mixer uncontaminated by even those small amounts of foreign bodies which detract from the quality of the concrete.

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MORE OUTPUT IN BRITISH SHIPYARDS

The output of British shipyards is rising most satisfactorily, but very few orders for new ships are being booked and the low volume of inquiries that are being received shows that shipowners are not yet convinced that now is the time to rejuvenate their fleets. There is, however, growing confidence that the flow of orders will soon be resumed, and supporting evidence is provided by the increase in orders received by German

yards which began during the summer. In the first quarter of the year the German shipbuilding industry booked orders for only 43,000 tons of new ships, compared with an output of nearly 230,000 tons. Orders received during the second quarter totalled over 150,000 tons and the improvement has continued (Weekly Survey note of September 24). As the bulk of these orders are for export, they may be interpreted as a sign that, provided they can have new ships quickly, shipowners will replace old ships by more modern tonnage which can be operated at a profit even when freight rates are low.

Lloyd's Register Shipbuilding Returns, published last week, show that output of British yards during the 12 months ending September totalled 1·5 million gross tons of merchant vessels, the highest level reached since the war. New orders during the quarter amounted to only 50,000 tons, bringing the total for the first nine months of the year to 282,000 tons (188 ships); cancellations during this period totalled 276,000 tons (29 ships). New orders have been mainly for small dry cargo vessels, for which delivery delays are much the lowest. We believe this to be the beginning of very substantial orders for dry cargo tonnage, much of it specialised, which should enable the British shipbuilding industry to maintain its rate of output at a very high level during the next few years.

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COURSE FOR MANAGERS

Large undertakings always face the problem of recruitment to their top management from men whose background is that of a special function or a limited area of responsibility. This has long been recognised in the Army, which sends its promising young officers back to school at the Staff College. For some years now industry has been experimenting with similar methods. To-day there are in the United States a large number of courses for business executives. These vary from the elaborate twelve-months' residential course for Sloan scholars at the Massachusetts Institute of Technology, and the three months' Advanced Management Programme at Harvard, to courses involving attendance on one or two evenings a week over a fairly long period, such as that at the University of Chicago. In addition to these courses at external institutions, more and more of the larger American companies are running their own executive development programmes in their own organisations.

In this country the initiative in residential courses was taken by the Administrative Staff College at Henley with its three-months course and, during the past year, the British Institute of Management has been running a series of four-weeks courses in London. In an article in the October number of the Journal of the British Association for Commercial and Industrial Education, Brigadier Garforth describes an experimental management development course organised by Tube Investments, Limited, in their companies in the Birmingham area. The number attending was thirteen, with an age range from 25 to 40 and with educational backgrounds from first-class honours to those whose formal education ended at the statutory school-leaving age. The course consisted of three sessions, each of ten single days in consecutive weeks. Subjects covered included effective speaking and writing, running a meeting, current affairs, the human factor and the study of two books: Brech's *Principles and Practice of Management* and Hutton's *We Too Can Prosper*. In addition there were a number of lectures on special social or industrial subjects, and the work of different functional departments was described by members of the T.I. staff. Case studies, some of general interest and some based on actual situations that had arisen in the T.I. organisation, were also discussed. As happens in all courses of this type, the quality of discussion and of interest improved markedly during the period of the course. The article concludes with an interesting summary of the advantages and disadvantages of this type of course in comparison with a continuous residential course.

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NEW BOOKS

There are so many engineering books published to-day that anyone who is at all interested must recognise the value of a readable and up-to-date guide, whether he deals with books on a large scale as a librarian or, like most engineers, would wish to be advised of a new book in his own field. Two weeks ago in ENGINEERING we effected a change which should come near to meeting that need. The Books Received column now includes, in addition to the customary bibliographical details of each book, brief notes which indicate its scope and purpose. These notes amplify the title; they are facts about the book, not editorial comment or opinion. As in the past, the more notable books are selected for subsequent review. We hope this will improve our service to readers of ENGINEERING. As far as we are aware, our notices and reviews now constitute the most comprehensive up-to-date guide, published in Britain, to new books on all branches of engineering.

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DIESEL LOCOMOTIVES

The effect of changing industrial conditions abroad on traditional British exports is well illustrated in the Survey of World Markets for Railway Locomotives prepared by the Board of Trade as a result of a deputation from the Amalgamated Engineering Union which recently met the President to discuss the problems of the locomotive industry. The picture is dominated by the growth of Diesel traction in most of the traditional markets for steam locomotives. The newly developing countries of the East and of South America are almost all concentrating on Diesel power, mostly with electric, but occasionally with hydraulic, transmission.

Unfortunately, as the British Productivity Council Report on the Diesel locomotive industry pointed out, the export market is virtually the only outlet for main-line Diesel locomotives manufactured in this country. Only five main-line Diesel locomotives are in experimental use by British Railways and the majority of shunting engines are manufactured in the railway workshops using engines and electrical equipment supplied by private firms. It is, therefore, not surprising that British firms find it hard to meet continental and American competition, based as it is on a scale of production which provides the benefits of specialisation and standardisation.

Another factor which has advantages for the Americans is the various assistance schemes for under-developed areas. For instance, Canada is making a gift of 120 locomotives to India under the Colombo Plan and a further hundred are to be financed by the U.S.A. through the Technical Co-operation Administration. The long-term credits which German manufacturers have been able to offer have also, no doubt, assisted their competitive position.

In view of the sharp decline in the market for steam locomotives the industry is faced with a difficult choice: whether to attempt to compete for the more standardised main-line types or to concentrate on smaller and more specialised designs. The future may well lie not with the Diesels, but with the gas-turbine and, in that case, technical leadership may at first count for more than price.

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ELECTRICITY AND PRODUCTION

In the Chairman's address which he delivered to the Utilisation Section of the Institution of Electrical Engineers on Thursday, October 21, Mr. J. I. Bernard pointed out that a greater amount of power was available to the American operative than to the corresponding worker in this country. There were a number of reasons for this, but an analysis of production methods had established two general relations: first, that the horse-power *installed* indicated the method of production and, secondly, that electricity *consumption* indicated the quantity of production. It would be helpful in advising works managers and production engineers in this country if figures of this kind obtained in one factory could be compared with those from another in the same industry as an indication of the extent to which modern methods of mechanisation had been adopted.

Mr. Bernard went on to point out that from its original application to small muffles for heat treatment in the laboratory the use of electricity had now spread to practically all trades. Over 90 per cent. of the high-grade brass was melted electrically and the arc furnace was now beginning to be used for the production of plain carbon steel. Whenever local heating had to be provided for any purpose it could be generated more quickly and more precisely by induction heating than by any other method. The use of high-frequency induction and very-high-frequency dielectric heating had provided some notable aids to higher productivity. Capacitance currents gave an alternative method of heating non-metallic materials. The electrical method should also be considered whenever measurements or inspections had to be made which required more than the unaided eyes or which had to be conducted on large numbers of identical articles.

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RESEARCH CONSULTANTS

In his address as Chairman of the Automobile Division of the Institution of Mechanical Engineers, Mr. J. H. Pitchford drew on his exceptional knowledge and experience of research on internal-combustion engines. The firm of Ricardo and Company, Limited, of which he is managing and joint technical director, occupies a unique place in this field. He remarked on the curious fact that it is generally the large firms—who, one would think, are self-sufficient—that make the greatest use of Messrs. Ricardo's services. Another noticeable feature, he said, was the great difficulty in coming to any satisfactory working arrangement with firms across the Atlantic. In spite of language difficulties, it had always been easier to deal with a reputable firm in a European country than to make even the most simple working arrangement with an American company. It might be argued, he said, that geographical distance makes for difficulties, but to-day it was scarcely more difficult to visit the United States than Italy or Greece, for instance, and India was already showing a desire and readiness to take full advantage of specialised technical knowledge and experience. Other countries in a similar stage of development to that of India also have the opportunity to use the unrivalled services of British firms and consultants, provided the authorities in these countries are aware of these firms; they are honoured and familiar names to British engineers but they may be quite unknown to potential customers overseas.

TECHNICAL EVIDENCE AT THE COMET INQUIRY

We give below a summary of the principal technical evidence given up to the end of Friday, October 22, at the Court of Inquiry into the Comet disasters at Elba and Naples which resulted in the loss of 56 lives. The Inquiry opened at Church House, Westminster, on Tuesday, October 19. The proceedings are expected to last 16 days.

Lord Cohen is presiding as Commissioner, with three assessors, Sir William Farren, C.B., M.B.E., F.R.S., Professor W. J. Duncan, C.B.E., F.R.S., and Air Commodore A. H. Wheeler, O.B.E., M.A.

Sir Lionel Heald, Q.C., M.P., for the Crown, said when the inquiry began "This is a fact-finding tribunal. We are not here to attack or defend anyone. Our sole task is to represent the public interest and give, under the direction of the Tribunal, all such assistance as we can in finding out what the true facts are."

Referring to the work of the chief witness, Sir Arnold Hall, director of the Royal Aircraft Establishment, Farnborough, in leading the investigation into the cause of the accidents, Sir Lionel said "Sir Arnold's report on the examination of the wreckage and the conclusions to be drawn from it will, I believe, be generally regarded as one of the most remarkable pieces of scientific detective work ever done. I believe also that as regards his main conclusions they will in general command acceptance as to their soundness."

Sir Arnold began his evidence by explaining how he was called in by the Government to investigate the two Comet crashes. The results of the investigation had been embodied in the report which he now produced.

Explaining the general principles of the investigation, Sir Arnold said it was in two parts, the examination of the wreckage of Comet Yoke Peter as it was received and an examination of the technical properties of the aircraft.*

Sir Arnold explained, "We first formed the impression that the aircraft broke up probably into about six main pieces. There is the nose of the fuselage, the outer end of the fuselage, the centre section containing the power plant, then there was the starboard wing tip and the port wing tip and finally the top of the centre of the fuselage.

"We rather formed the opinion that these were the six main pieces into which the plane fell. That was a preliminary judgment and lined up with the impact damage and also lined up with the plot of the wreckage on the bed of the sea."

"The main separations appeared immediately to line up with the pattern of the debris as it was reported to us by the Navy.

"We concluded that the first disruption of the aeroplane took place in the region of the top centre of the fuselage, and there was in fact a very violent disruption of the pressure cabin."

At this point Sir Arnold took in his hands a scale model of the Comet, which had been so constructed as to enable it to be broken up into the component parts. He first removed two pieces of the model—one in each hand—from the roof of the cabin, with a swift outswept movement of his arms, saying that it seemed that the centre of the cabin first disrupted in a violent way.

"We then think that almost simultaneously the rear fuselage and the front fuselage fell in what I will describe as a downward direction."

Sir Arnold explained that the view that the pressure cabin was the first to disrupt was founded on two approaches, the first consisting of the marks the cabin made when pushed sideways and the second was on evidence in the parts themselves, particularly on the port wing where there was a series of scratches and paint marks going out laterally. If those marks were plotted geometrically they lined up with each other and suggested that they were made by a single piece or pieces going over the wing. Many of the marks contained blue and gold colouring believed to be the blue and gold from the line on the side of the aeroplane. One particular indentation on the wing was clearly made by one part of the side of the fuselage, at high speed.

"We believe that at that point this centre part caught fire, not unnaturally, because this failure had disrupted the integral tanks and released quite a good deal of fuel. It then proceeded downwards in an inverted manner."

Earlier, in describing various diagrams appearing in the report, he said it was immediately clear that there was a physical separation, for example on the port wing. The starboard wing was completely broken through. Underneath the nose, when one looked at the wreckage there was very considerable crushing damage which plainly showed that that hit the sea coming down in that way.

In contrast there was crush damage on the top side of the centre part of the wing which indicated that it fell upside down. That was an immediate first indication that the nose of the aeroplane and wing were separated. There was a major failure in the rear part which showed a downward failure from the tail. The parts were all picked up together.

FIRE WAS SECONDARY

Sir Arnold said the aileron on the port wing also showed paint scratch marks. The paint on the outside of the fuselage was a proprietary brand with a unique consistency and could easily be identified from the paint inside the cabin. The paint on the aileron was the same as that on the outside of the fuselage. From these scratch marks it was deduced that the cabin disrupted before the wing. Another important tracer in assessing the sequence of break-up was fire marks. In some cases where two pieces had been joined together and broken, one piece bore marks of fire, the other none, thus indicating that the fire was secondary and occurred after the first major failure.

Only five electrical fuses had blown. All the others were intact and it had been possible from this to deduce that interruption of the electrical circuits had taken place somewhere near the centre top of the fuselage.

One of the battered and twisted passenger seats—number five from the rear part of the plane—was then carried into court. Pointing with his hand, Sir Arnold explained that the double twisting of the seat indicated two types of failure. First there had been a violent forward motion caused by the suction wave at the disruption of the cabin when the plane resembled what had been called "a compressed-air gun," and secondly, a violent backwards twisting in the seat as the fuselage struck the water.

There would be a big rush of water into the cabin when that occurred which would wrench the seat backward and tear anything away that was still attached to the floor.

Sir Arnold said that he came to the conclusion that the aeroplane had split along the top centre line of the fuselage in the region of what were known as the A.D.F. aerial windows just aft of the crew compartment.

There was in that piece of wreckage a compression buckle which was very characteristic of released pressure. That sort of buckle had been reproduced in a test on another Comet, Yoke Uncle, which had produced a fracture in the region of an escape hatch on the side of the aeroplane.

Sir Arnold agreed with Sir Lionel Heald that apart from the fact that the windows in the two aircraft—"Yoke Peter" and "Yoke Uncle"—were in different places, there was a close correspondence between the two fractures, each symptomatic of a sudden release of pressure.

Sir Arnold said he considered the break-up had occurred at something like 25,000 or 30,000 ft. After the initial break the parts of the aircraft took about three minutes to descend to the sea. The centre section of the wing had been badly burnt and his staff at Farnborough had made attempts to assess how long the fire must have been burning to produce the damage it had caused. In many areas the fire had been extremely intense. Molten metal had actually run. The rear spar ribs had become delaminated and in some cases burnt through.

"We made some experiments with representative structures and representative fires and we believe the fire must have been burning for about three minutes. It took us three minutes and more to produce damage of that type," he said. This was confirmed by experiments that had been made with aerodynamically similar models.

"The time of descent of the models, when we caused them to break up in the way we think the aircraft had broken up, was about two and a half minutes, which ties in with the three minutes we believe the fire burnt in the real aircraft. The model also produced a pattern of wreckage when broken up which was very similar to the pattern of the real wreckage found on the sea bed."

Sir Arnold said the model tests had proved that the rear part of the fuselage and the tail would descend "open end" first. That was contrary to what they might have thought.

Explaining a series of instantaneous photographs taken in rapid succession and reproduced in one section of the report, Sir Arnold said that they were photographs showing what happened to an experimental cabin made of Perspex equipped with seats as in an aeroplane and with dummy passengers. The cabin was charged with air at 8¼ lb. per square inch pressure above that of the air outside. They caused the cabin to burst at the top and a series of photographs were taken; the first photograph taken at a time only 0·006 second after the release of the top, showed no particular disturbance in the cabin.

"The suction wave had not yet arrived," explained Sir Arnold.

The second photograph taken 0·03 second after the release of the top of the cabin showed some of the seats going back. Succeeding pictures showed the increasing effects until a picture taken 0·1 second after the release showed what Sir Arnold described as the "development of complete chaos in the cabin."

He went on: "At 0·6 second you see a dummy passenger hitting the roof with considerable violence and seats flying about in all directions. I think that something like that happened in Comet Yoke Peter and the severe skull injuries were caused by something like you see happening to these dummies." Other pictures displayed by Sir Arnold showed one of the dummies hurtling through the hole.

Sir Arnold agreed with Sir Lionel Heald that having arrived at this point they arrived at the conclusion that the occasion of the accident was a failure of the pressure cabin in the region of the rear A.D.F. window. There were, of course, several possible causes.

Sir Lionel suggested that the most obvious way of producing abnormal pressure would be an explosion—a bomb—either a conventional bomb or possibly hypothetical explosives.

Sir Arnold replied "I think the first thing to say is that our explosives experts at Farnborough have been all over this wreckage with considerable care to look for the kind of evidence one would expect to be left by a bomb and they found no such evidence."

Experiments had shown that explosion with hydraulic mist was impossible except by an electrical spark. It would not, for instance, explode through a glowing cigarette.

POSSIBLE FAULTS

The possibility of abnormally high cabin pressure was also discounted. Wreckage showed that the cabin failure took place while the cabin was functioning in a normal way.

Sir Arnold said that another possibility they had had to consider was that of abnormally high tail loads which might have led to the disruption of the cabin. He would not have expected it to cause a disruption near the A.D.F. windows but rather to the rear of those windows. Tests were done on the tail plane itself and it was shown to be structurally sound. Another possibility might be failure of the automatic pilot or the power-operated control system, or mishandling of the controls by the pilot himself. He was satisfied that there was no ground for attributing the accident to those possible faults.

At this point, Sir Lionel said he thought it should be made quite clear that all possible failures and troubles were considered in order to be complete in the scientific approach to the matter, even assuming, contrary to what Sir Arnold believed, that it was not the pressure cabin that failed. For example, there was the question of the possibility of fire in the trailing edge. Sir Arnold said that particular factor did not cause the disaster at Elba as was clearly demonstrated by the wreckage, but they sought to make an investigation of where fuel which was vented from the tanks might go.

They had reports from B.O.A.C. that a considerable amount of fuel could vent from a plane at early stages. That was not unusual, and a vent was provided for the purpose.

"We made some experiments in the normal course to see whether there was anything that would cause that fuel to become ignited," continued Sir Arnold. "We devised a technique whereby we used radioactive isotopes and flew the aeroplane on radioactive fuel. We determined that fuel could get quite close to the shrouds of the jet pipes."

The temperature of the shroud in flight was found to be 350 deg. C. whereas the ignition temperature of kerosine—which was variable—was a minimum of about 250 deg. C. The shroud was consequently 100 deg. C. above the minimum temperature at which kerosine would ignite, and although there was good, deliberate ventilation, the matter had been mentioned in the Farnborough report, although he had no doubt that the chances of ignition were very small. He thought steps could readily be taken to remedy that matter without great difficulty. Fire was certainly not the cause of the Elba accident.

Dealing with the question of mis-operation of the re-fuelling system, Sir Arnold said there was a

* An article on the tests carried out at Farnborough appear on page 573.

remote possibility of such damage but even if the tanks were widely damaged in that way the loss of strength to the aircraft would be relatively little.

Sir Lionel: With regard to the Elba case, it is your view that it did not cause the accident.—Yes, it is my view that it was not the cause.

Sir Lionel said that he had also received correspondence, among them suggestions that the Comets might have come into contact with something like flying saucers or a meteorite or a stratospheric gremlin, and he said to Sir Arnold: "Would you explain why it is that we can write off these things?"

Sir Arnold: "The probability of the Comet meeting a foreign body other than another aircraft is extremely remote and certainly there is no record of evidence as such that we could take real notice of it." The evidence of the wreckage showed that it did not come into contact with any large foreign body.

Sir Lionel said that it had been suggested in some letters sent by the public that the adhesive material used in the plane might have failed.

Sir Arnold replied that very careful consideration had been given to that possibility but examination of the wreckage made it quite plain that there had been no failure of the Redux adhesive bonding.

FATIGUE

Sir Lionel: What is your view, then, for the cause as a result of your investigation?—Sir Arnold: We have come to the conclusion that the primary failure was in the pressurised cabin and that the very probable cause of that failure is a phenomenon known as "fatigue."

In reply to further questions, he said that one could not rely on getting standard results with regard to fatigue when dealing with the kind of material concerned in this case—aluminium alloys.

Sir Lionel: You are not suggesting that there is any defect or lack of standardisation in the aluminium alloys?—Not at all. In fact we have taken test specimens of the material from "Yoke Peter" and it is in every case up to or better than specification.

Using standard material in complicated structures, there was a large spread in the time over which fatigue failure might take place. A weak specimen might fail at about one-third the life of an average specimen and a strong one might have about three times the life of an average specimen.

The maximum stress concentration in the case of the Comet was to be found near the windows. They measured the stress concentration round the windows with electrical strain gauges.

Describing experiments with "Yoke Uncle" in the fatigue testing at Farnborough, Sir Arnold said that when failure occurred near the forward escape hatch the structure at that point had a peak stress of 45,700 lb. per square inch and it was deduced that that stress was, in practice, reached two or three times per flight. The ultimate static strength of the material was about 65,000 lb. per square inch (29 tons) so that failure occurred at 70 per cent. of the ultimate.

Sir Lionel Heald: The safety factor or margin is not a very large one?—Sir Arnold: It is not.

Tests with strain gauges showed a similar stress concentration round the rear A.D.F. window (where failure was believed to have occurred in "Yoke Peter") and the forward escape hatch (where failure occurred during tests on "Yoke Uncle" at Farnborough).

Sir Arnold said although it was not possible to detect when fatigue was likely to occur in material, after the actual break, the evidence of fatigue could be found.

The wreckage from the Elba crash was examined microscopically at the rear A.D.F. window and the characteristics of fatigue fracture were identified at one particular point.

DRILLED HOLES

Referring to cracks which had been observed and which were believed to have occurred during manufacture, because they had been drilled at their ends to stop propagation, Sir Arnold said that they were not the primary cause of the accident but might have accelerated the onset of fatigue and brought it farther forward in time.

"Although we did find a short fatigue life of the cabin, we did find it to be a most admirable aeroplane and most excellently engineered."

Asked by Lord Cohen whether cracks which were virtually undetected might form the starting point for fatigue failure, Sir Arnold said, "There is nothing better to cause a local stress concentration than a very narrow crack. You often find fatigue will strike at such a point first."

Sir Arnold was asked by Sir Hartley Shawcross, appearing for the de Havilland company, to make clear certain points which had arisen on the question of the manufacturing cracks found in the metal.

He explained in answer to Sir Hartley that the fatigue failure in the accident happened to go through an existing crack. If it had not gone through that existing crack, it would still inevitably have occurred in some other place.

Sir Hartley: We are not disputing the existence of fatigue, but I wanted to get fairly the sequence of events.

Lord Cohen: You say that it would have occurred inevitably. Would it have occurred at the same time?—Yes.

Sir Arnold: There were in existence certain cracks made during manufacture. When the failure to the aeroplane took place I believe it started at a fatigue crack, developed not during manufacture at all, but during the life of the aeroplane. When the burst took place it so happened that the failure ran through a manufacturing crack. It started at a fatigue origin.

Sir Lionel Heald: "How could a manufacturing crack accelerate the process?"

"The difficulty," Sir Arnold replied, "is that if the manufacturing process used is such as to create cracks which are observable—and plainly it is in this case—then one cannot be completely certain that there are no incipient cracks, a crack you cannot see, and that those incipient cracks might form a point at which fatigue might attack.

"I think it is wise not to use a manufacturing process which causes cracks if the structure is a primary structure taking a primary load, not because cracks have had anything to do with it, but because there may be cracks you do not see and therefore would be unattended and might form a fatigue origin."

Lord Cohen: That answer gives rise to the question whether there is a process which will avoid all risks of incipient cracks.

Sir Arnold: I think that could be done. That is a matter which the de Havilland constructional engineers could speak on better than I, but I should be surprised if it could not be avoided.

Dr. Percy B. Walker, of Park Road, Camberley, Surrey, said that since 1945 he had been head of the Aircraft Structures Department at Farnborough. He had made a speciality of fatigue problems. After the second Comet accident at Naples he made a theoretical review of the possible causes before any wreckage had been recovered.

"There was evidence that aroused my suspicion that fatigue of the pressure cabin might be the cause. Both accidents occurred while the aircraft were climbing and consequently approaching their maximum differential pressure.

"Unless that was a coincidence, which was always possible, the implications were that that was the point where fatigue failure could be expected to occur, where the load had reached its top limit or had reached at least half its top limit.

"There was only one objection to that tentative theory and it was the quite understandable one, in the state of our knowledge then, that fatigue in the pressure cabin could have occurred after such a short lifetime."

Dr. Walker said that he was in charge of the fatigue tests to "Yoke Uncle," in which a major failure of the pressure cabin occurred after 9,000 hours. He said that he carefully examined the window and various cracks after the failure. So far as he knew no manufacturing cracks were found in this particular region where the failure occurred in the tested aircraft.

The result of the test was that the Comet "Yoke Uncle"—the aircraft used in the test—apparently had a life which would be rather more than three times that of the Naples aircraft and rather less than three times that of the Elba aircraft.

Asked whether he could establish the life of an aircraft structure or indeed of a component simply by another one, Dr. Walker replied: "No, that is impossible. No two aircraft are alike in their fatigue properties so far as is known."

SCATTER OF FATIGUE LIFE

Dr. Walker was asked what sort of life "scatter" was expected so far as structures of this type were concerned.

He replied: "Well, I would say one-third the average to three times the average. An overall ratio of 9 to 1 is not at all unusual and could be more than that."

Mr. J. P. Graham, Q.C., appearing with Sir Lionel Heald for the Crown, referred to the manufacturing cracks and Dr. Walker said: "My view on those cracks in relation to the accident is that I do not think they accelerated the fatigue failure or shortened life."

Mr. Graham: On the other hand, there may be incipient cracks which do accelerate failure?—Yes, that is possible.

And some of those incipient cracks you may not be able to see?—That is possible.

You don't, in fact, see any cracks of that type in the wreckage here?—No.

Dr. Walker said that cracks developed in the wing of "Yoke Uncle" during tests after about 6,000 hours, but that was a secondary part of the experiment. They were detectable and he did not think they had a fast progression rate.

Mr. Graham: From the Elba accident, it is clear that the wing did not fail?—Yes.

Dr. Walker added: "I think this problem—fatigue—can be dealt with when it is known as it is now."

Sir Hartley Shawcross: Did you find traces of any manufacturing crack in the area where your fatigue test produced a failure in "Yoke Uncle"?—I did not see any.

Is it a fact that in "Yoke Uncle" there was found a manufacturing crack near the rear A.D.F. window?—I think that is correct.

Dr. Walker, cross-examined by Sir Hartley Shawcross, said that the manufactured crack was dealt with by drilling what was called a stopper hole.

Sir Hartley: Is it right to say that in spite of repeated loadings to which "Yoke Uncle" was submitted that that crack in the rear A.D.F. hatch did not propagate in any way or give rise to the development of any fatigue at that point?

Dr. Walker replied that the A.D.F. window remained intact in this particular test.

B.O.A.C. INSPECTION

Evidence was then given by Mr. Geoffrey Corfield, an aircraft engineer, employed by B.O.A.C. as a fleet inspector of their Comet fleet.

He explained that it was assumed that an aircraft was going to fly 4,800 hours in two years and the maintenance plan was based on that assumption.

The figure of two years was generally accepted as the period at which the aircraft must be thoroughly inspected—the whole of the aircraft.

Over the period of two years a series of checks was made. In the case of the Comet aircraft a special procedure was introduced after the accident to "Yoke Peter" to detect any fatigue cracks in the main plane, should they occur.

A meeting was held between the de Havilland Company, the Air Registration Board and British Overseas Airways Corporation to decide what lines that inspection should take, and was later officially introduced into the maintenance schedule.

Replying to Lord Cohen, Mr. Corfield said that there was no inspection called for of the cabin for fatigue cracks.

Mr. J. M. Shaw (representing some of the victims): Were you aware that there were certain manufacturing cracks on some, at any rate, of the Comets?

Mr. Corfield: I was not.

So that no inspections were carried out to see whether these cracks had spread?—I think it has been clearly said in evidence today that some of those cracks were in places where they could not have been seen anyway.

As far as you know, B.O.A.C. were not aware of the existence of these manufacturing cracks?—That is so.

If they had been aware of them would they have taken steps regularly to see whether they had spread?—Definitely yes.

Lord Cohen: I understand that the drilling of the little holes was regarded as a recognised way of remedying what are called manufacturing cracks?

Mr. Corfield: One would have to consider in what part of the structure a crack was. If it was in a part that was not important then it could be stopped by what we call "locating."

Lord Cohen: Would you have expected de Havilland's to call special attention to them in delivering them to B.O.A.C. or to say nothing if they had done everything in connection with the matter?—We would hardly expect to have an aeroplane with cracks in it unless they were in a very minor part of the structure.

Sir Hartley Shawcross: I hope it is not suggested that there were cracks in the wing when we delivered the aircraft.

Lord Cohen: Mr. Shaw was asking about the manufacturing cracks which Sir Arnold referred to which had been dealt with at the time of manufacture by the drilling of a hole. You will no doubt deal with that matter when you call your evidence.

Sir Hartley: Experts say that in the one place they did not aggravate the accident and that in the other place in spite of 16,000 hours of testing in the tank they remained absolutely stationary.

Mr. Shaw said that the report showed that one crack in "Yoke Uncle" (the test aircraft) had spread.

Sir Hartley Shawcross: Nothing of the kind. With respect, it does not show that the crack in "Yoke Uncle" had spread in the course of testing.

Lord Cohen: That is a matter for argument. We will not pursue the matter now.

The Inquiry adjourned until Monday.

Obituary

MR. H. NIMMO, C.B.E.

A Leader in Electricity Supply

We regret to record the death of Mr. H. Nimmo, which occurred at Matching Green, Harlow, Essex, on Monday, October 25, at the age of 69. He was well known to electrical engineers for his work on the supply side of the industry and for the great interest he displayed in many of the other activities of the profession.

Henry Nimmo was born on July 28, 1885, and was educated at Airdrie Academy and the Coatbridge Technical College. After receiving practical training as a mechanical and electrical engineer he obtained a position on the erection staff of the British Westinghouse Electric and Manufacturing Company. In 1907, he was appointed chief electrical engineer of the Oakbank Oil Company and five years later became assistant engineer to the Rangoon Electric Supply and Tramway Company.

In the early part of 1914, he was appointed Electrical Adviser to the Government of Burma, a position he held until 1929, although his term of office was interrupted during the war by service in the London Electrical Engineers, Royal Engineers. On his return to Burma, at the conclusion of hostilities, he also acted as consulting engineer to the Rangoon municipality and other bodies and as officer commanding a Field Company, Royal Engineers in the local forces.

In 1929, Nimmo was appointed chief engineering inspector of the Electricity Commission in this country on the retirement of Colonel T. C. Ekin and became one of the Commissioners in 1945, in succession to Sir Leonard Pearce. On the passing of the Electricity Supply Act of 1947, he acted as Area Liaison Controller during the transfer of the electricity supply industry to the new authority. He was appointed chairman of the Southern Area Electricity Board in 1948, a position he was still holding at the time of his death. He was also a part-time member of the Central Authority in 1952-53.

Nimmo was appointed a Commander of the Order of the British Empire in 1953. He was elected a member of the Institution of Civil Engineers in 1936. In 1920, he became an associate member of the Institution of Mechanical Engineers and was transferred to the class of member in 1923. His connection with the Institution of Electrical Engineers began in 1911, when he was elected an associate member, being transferred to the class of member in 1920. He served in the capacity of honorary treasurer to the latter body from 1950 to 1952. He was also chairman of the British Electrical Development Association in 1952-53, and had been a vice-president and member of council of the Conférence Internationale des Grands Réseaux Electriques (CIGRE) since 1951, and member of the Council and chairman of the British Committee of the Union Internationale des Producteurs et Distributeurs d'Energie Electrique (UNIPEDE) since 1949. He was a past-president of the Association Supervising Electrical Engineers and at the time of his death was president of the Engineers' Guild. He was a member of Council of the British Electrical and Allied Industries Research Association and of the British Electrical Power Convention and a past-chairman of the Isle of Man Hydro-Electric Commission.

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DR. G. P. DOUGLAS

Wind Tunnels and Aerodynamics

We record with regret the death of Dr. G. P. Douglas, O.B.E., M.C., D.Sc., F.R.Ae.S., at his home in Camberley, Surrey, on Saturday, October 16.

Georve Purves Douglas was born on September 22, 1892. He received his education at George Watson's College, Edinburgh, and Edinburgh University. He served in the first World War and was awarded the M.C. In 1919 he was appointed engineer-in-charge of the wind tunnels at the Royal Aircraft Establishment, Farnborough, a position which he held until 1934, when he was appointed deputy-chief scientific officer and head of the aerodynamics department at Farnborough, where he remained until his retirement last year. Since then he had continued to act as a consultant to the department.

Among the various aerodynamic problems to which he contributed, in addition to the development of wind tunnels, he will be remembered for two lectures which he presented before the Royal Aeronautical Society—"Airscrews at High Tip Speeds" and "Cooling Problems." Dr. Douglas served on the Council of the Royal Aeronautical Society from 1946 to 1951 and was a member of the Society's Education and Examination Committee from 1946 to 1954.

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MR. E. W. HULME

Patent Office Librarian

Edward Wyndham Hulme, B.A. (Oxon.), formerly Chief Librarian at the Patent Office Library, died at Littlehampton on October 19, in his 95th year. He was a founder member and a vice-president of the Newcomen Society for the Study of the History of Engineering and Technology and contributed to the Society in 1920 the first paper to be printed in the Transactions, "An Introduction to the Literature of Historical Engineering to the Year 1640." In it he remarked that Biringuccio's *Pirotechnia*, the classical early work on metallurgy, published in Venice in 1540, was not yet available in an English edition. Twenty-three years later, when an English translation was produced by the American Institute of Mining and Metallurgical Engineers, he reviewed it for ENGINEERING (vol. 155, page 143) in a critique as remarkable for the evident clear understanding of mediæval technicalities as for the profound scholarship that it displayed, which those who knew him will remember as vividly and gratefully as they do the generosity with which he placed the fruits of his learning at their disposal.

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We regret also to record the deaths of :

MR. THEODORE STEVENS, B.Met.,Min.E. (Lehigh Univ., U.S.A.), M.I.C.E., M.I.E.E., at Herne Bay Hospital, Kent, on October 18, in his 90th year. Mr. Stevens, who had lived for a number of years at Herne Bay, was a consulting engineer who, in the early days of his career, had carried out work on the production of aluminium. Subsequently, he was employed on railway electrification operations and latterly had been engaged on consulting work in South America, Egypt, Palestine and Spain.

MR. ERNEST A. HERRING, on October 14, at the age of 75. He was a director of John Lynn and Co. Ltd., engineers and ironfounders, Sunderland. He joined the firm in 1900 and became a director 22 years ago.

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PERSONAL

British Insulated Callender's Cables Ltd. have announced the following board changes and appointments which become effective on December 1, 1954. MR. W. H. MCFADZEAN, chairman and chief executive, will become chairman and managing director. MR. D. W. ALDRIDGE will become deputy chairman. MR. H. J. STONE, deputy chief executive, will become general manager. MR. W. C. HANDLEY will become deputy general manager. DR. L. G. BRAZIER, director of research, will become director of research and education. MR. R. M. FAIRFIELD will be appointed to the board as director of production and engineering. MR. D. T. HOLLINGSWORTH will be appointed to the board and will give up his present position as chief engineer to take up an appointment in an associated company.

SIR MALCOLM TRUSTRAM EVE, G.B.E., M.C., Q.C., has been appointed to the board of Henry Simon (Holdings) Ltd., Cheadle Heath, Stockport, Cheshire.

MR. H. C. B. THOMAS, who has been a superintendent in the Mechanical Engineering Department, Royal Aircraft Establishment, Farnborough, since 1950, has been promoted deputy chief scientific officer and appointed head of the Mechanical Engineering Department at Farnborough.

PROFESSOR N. F. MOTT, M.A., D.Sc., F.R.S., Cavendish Professor of Experimental Physics, University of Cambridge, has been elected into a Professorial Fellowship of Gonville and Caius College.

The board of ASSOCIATED ELECTRICAL INDUSTRIES LTD., Crown House, Aldwych, London, W.C.2, have reorganised, with effect from October 11, the A.E.I. Ltd. companies into four groups, namely, the B.T.H. GROUP, the EDISWAN-HOTPOINT GROUP, the M.-V.E. GROUP, and the OVERSEAS GROUP. The chairman of the A.E.I. Ltd. becomes chairman of each of the Groups and, as announced on page 453 of our issue of October 8, MR. E. H. BALL, M.I.E.E., has been made group managing director of the B.T.H. Group, MR. A. N. E. MCHAFFIE, B.Com. (Edin.), group managing director of the Ediswan-Hotpoint Group, DR. C. DANNATT, O.B.E., M.C., M.I.E.E., group managing director of the M.-V.E. Group, and DR. I. R. COX, D.S.O., M.I.Mech.E., A.M.I.C.E., group managing director of the Overseas Group.

MR. EWEN H. SMITH, managing director of David Rowan & Co. Ltd., Glasgow, has been re-elected chairman of the National Association of Marine Enginebuilders, for 1954-55. MR. P. L. JONES, M.C., director of Swan, Hunter, and Wigham Richardson Ltd., Newcastle-upon-Tyne, has been re-elected vice-chairman.

MR. W. J. EBBEN, education and training officer of the Fraser and Chalmers Engineering Works of the General Electric Co. Ltd., has retired after 37 years of service with the company.

LIEUT.-COL. J. F. TODHUNTER, on medical advice, has relinquished his appointments as director and general manager of Murex Welding Processes Ltd., Waltham Cross, Hertfordshire. MR. J. M. WILLEY, deputy general manager of the company since October, 1951, has now been appointed to succeed Colonel Todhunter as general manager.

MR. E. RANSOM HARRISON, who has been chairman of the Rover Co., Ltd., since 1932, has resigned from the board on account of ill-health. MR. H. HOWE GRAHAM, who was first elected to the board in 1932 and became deputy chairman in 1952, has been elected chairman.

MR. H. V. CLARKE has resigned his position as chief engineer to the Airspeed Division of the de Havilland Aircraft Co. Ltd., in order to direct operations at the Parkstone, Dorset, works of A. Felix Industries Ltd., 125 Edgware-road, London, W.2, of which company he is a director.

The Brush Group, Ltd., announce that MR. S. WEBSTER, at present managing director of Bryce Berger, Ltd., is to become deputy managing director of the National Gas and Oil Engine Co. Ltd. MR. B. D. GIORDAN, at present works director of Mirrlees, Bickerton and Day Ltd., is to become managing director of Bryce Berger, Ltd. MR. D. G. HAWKINS, at present general manager of the National Gas and Oil Engine Co. Ltd., is to become assistant Group sales director. MR. R. G. HOOKER, at present works manager of J. and H. McLaren Ltd., is to become general works manager and director of the Brush Electrical Engineering Co. Ltd. MR. B. R. CANT, at present personal assistant to the Group managing director, is to become works manager of J. and H. McLaren Ltd.

MR. DONALD BASTOW, B.Sc.(Eng.), M.I.Mech.E., has been appointed technical assistant to the managing director of Metalastik Ltd., Evington Valley-road, Leicester.

MR. W. E. WATSON, M.B.E., who has been works manager of the Cheltenham factory of Smiths Aircraft Instruments Ltd., since 1940, has been appointed to the company's board as works director.

MR. R. A. HARDING, director and general manager, Macrome Ltd., since 1952, has been appointed managing director of the firm.

MR. W. G. GENTRY, chief designer in the constructional department of the South Durham Steel and Iron Co. Ltd., Stockton-on-Tees, has been elected chairman of the Northern Counties branch of the Institution of Structural Engineers.

MR. B. H. HARBOUR, M.Inst.T., who is at present operating manager, country omnibuses and coaches, London Transport Executive, has accepted the invitation of the Minister of Transport and Civil Aviation to become a full-time member of the Executive.

MR. H. DOUGLASS, general secretary of the Iron and Steel Trades Confederation, has been appointed, by the President of the Board of Trade, to be a member of the advisory council of the Export Credits Guarantee Department.

Letters to the Editor

THE MECHANISM OF A SIMPLE DRAWING OPERATION

Blank Holding and Lubrication

SIR, During the last few years I have made a few observations on the practical aspects of deep drawing. As I compared my few results with those of Professor Swift (ENGINEERING, October 1, page 431), I began to feel that certain conclusions do not seem to apply to blanks having thicknesses of the order of 0·01 in. combined with high diameter to thickness ratios.

A particular point is that of blank-holder pressures. Professor Swift concludes that the blank-holding force has little effect on the strain distribution in the critical regions of the drawn cup. I have, however, made observations of strains in drawn brass shells which were produced from 0·011-in. stock using a relatively small double-action press. The pressure pad was cam-actuated and the load on the pad was adjusted by a screw system. Shells were drawn in the first case at pressure adjustments just inside the lower critical value and in the second case just inside the upper critical value. The strain distributions are shown in Fig. 1; details of the drawn shells are also given.

The difference between the strains at the punch radius zone is around 3 per cent. and at the rim the strain difference is around 7 per cent.; it will also be noted that the general distribution differs near the rim. A further point to note is the difference in the average lengths, which under production conditions may or may not pass the inspector's gauge.

Another observation related to pressure pad loading is the effect of lubrication. Fig. 2 shows two shells manufactured from 0·011-in. brass strip using the same tools (except for the punch profile) as those mentioned above. The shells were made from consecutive blanks cut from the same strip and the tool settings were untouched. The shell A was drawn without lubrication while for shell B the tools were amply lubricated with lard oil. Shell A is reasonably good, but shell B has brought out the directional properties of the strip and is badly wrinkled. This, I think, helps to illustrate the sensitivity of thin stock to pressure-pad conditions.

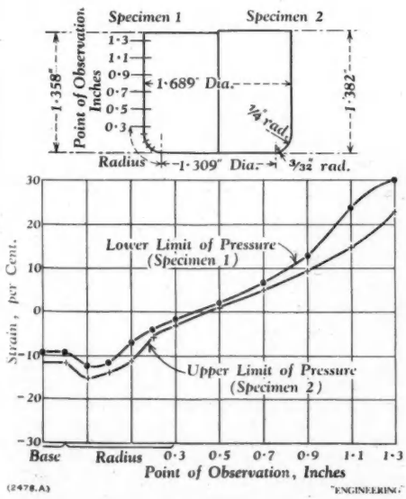

Fig. 1 Strain-distribution diagrams for the drawing of brass shells with pressure adjustments just inside the upper and lower critical values. Details of the shells are also given.

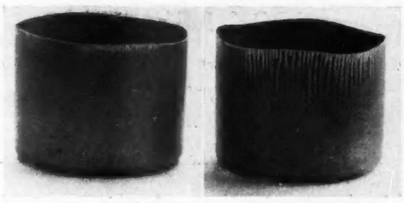

Fig. 2 Shell A (on left) was drawn without lubrication but the tools were amply lubricated with lard oil when used for drawing shell B.

The problems confronting the tester of thin metals are well known—for instance, tensile tests and elongation values are unreliable for strip below 0·03 in. because of increased notch sensitivity. Hardness values are susceptible to the anvil effect and we must revert to loads on the borders of micro-hardness testing, consequently the results become more structure sensitive. The Erichsen machine is normally the apparatus available to the small testing department, but is not satisfactory, according to Professor Swift, for predicting drawability because of lubrication effects. The Table below gives results of an experiment which I carried out to examine the effects of lubrication on the Erichsen values for various thicknesses of metal, although at this stage only two thicknesses have been dealt with. The results show that for thin metal the value changes by 5 per cent. while for thicker metal the value changes by 2 per cent., tending to indicate that thin metal is more sensitive to lubrication conditions, also the thinner metal is more dependent on good punch lubrication.

TABLE.—*Effect of Lubrication on the Erichsen Test* (3½-in. square specimens)

Material	Lubrication	Depth of Cup at Necking, mm.	Depth of Cup at Fracture, mm.
0·011-in. brass, 63–37, hardness 67·3 (D.P.N.—1-kgm. load)	None	12·4	12·5
	Soap solution	12·86	12·94
	Lard oil (punch only)	12·75	12·85
	Lard oil (full application)	12·98	13·04
0·0185-in. brass, 63–37, hardness 64·9. (D.P.N.—1-kgm. load)	None	13·13	13·22
	Soap solution	13·37	13·415
	Lard oil (punch only)	13·19	13·27
	Lard oil (full application)	13·46	13·53
0·018-in. aluminium, hardness 26·6. (D.P.N.—1-kgm. load)	None	8·9	9·07
	Soap solution	9·5	9·76
	Lard oil (punch only)	9·52	9·64
	Lard oil (full application)	9·5	9·615

The cup-drawing test certainly seems to have greater possibilities than other tests, but I think lubrication conditions will have to be placed on equal terms with the dimensional factors when dealing with stock of 0·01 in. and less. Also the accurate alignment of the blanks presents a problem which no doubt can be solved.

Yours faithfully,

B. FOGG.

20 Smithfield-avenue,
Hasland, Chesterfield.
October 20, 1954.

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FORM IN ENGINEERING DESIGN

A public lecture on "Form in Engineering Design" will be given by Mr. J. Beresford Evans at King's College, University of London, Strand, W.C.2, on Tuesday, November 2, commencing at 5.30 p.m. Tickets will not be required.

RAILWAY ACCIDENTS IN 1953

From the point of view of the travelling public, the main information of interest in the report* on railway accidents in 1953 is that there was only one passenger fatality in 71 million passenger journeys and one serious casualty in 27 million journeys. These satisfactory figures are not the best that have ever been recorded, but in this matter no uniformity between different years can be expected, as a single event may mar the record of an otherwise satisfactory year. This was illustrated in 1952, when, as a result of the Harrow and Wealdstone disaster, the totals for train accidents for the year were 133 killed and 1,302 injured. The corresponding figures for 1953 were 48 killed and 608 injured. The averages for 1946-1950 were 51 killed and 803 injured.

Public interest tends to be directed to train accidents, but in normal years, among which 1953 may be placed, movement accidents are responsible for the greater number of deaths and injuries. Movement accidents are those due to the movement of railway vehicles, but exclusive of accidents to trains. In 1953, 22 passengers were killed in train accidents, but 44 were killed in movement accidents and 4,576 were injured. The number of movement accidents to passengers has been fairly regular over a number of years, the averages for 1946-1950 being 56 killed and 4,990 injured. This particular type of incident appears to be largely out of the control of railway staffs and management as its principal causes are misadventure and carelessness and misconduct on the part of passengers themselves. Movement accidents to railway servants are more excusable, or, at least, understandable, owing to the risks to which they are exposed. It is satisfactory that both deaths and injuries under this heading were well below the averages for 1946-1950.

Accidents at level crossings, which are recorded as train accidents, are in many cases, but not all, outside the control of railway staffs. There are 4,256 public-road level crossings with gates, 249 without gates, and 21,311 occupation crossings, that is, connecting fields or footpaths. There were 256 accidents at level crossings, involving 45 casualties in 1953; these figures are above the averages for recent years. In some of the cases, the accidents were due to gatekeepers not observing official instructions, but in others they were due to oversight or simple foolishness on the part of road users, as in the case of a motor cyclist who pushed his machine through the wicket gate, in face of an approaching train, and was killed. The main gates were closed and the motor cyclist was warned by the gatekeeper and two other cyclists.

The most satisfactory information contained in this report is that "there is no longer any serious shortage of the materials and plant which are required to keep the equipment of the railways in sound condition." This, unfortunately, does not mean that there is no longer any difficulty in recruiting and retaining good maintenance men, but the improved material position is clearly shown by the fact that the total number of failures in 1953 was 2,675, compared with 3,022 in 1952 and an average of 4,382 for the period 1946-1950. Coupling apparatus continues to be the main cause of breakdown, the total for 1953 being 2,100; in 1946-1950 it was 3,702. Coupling failures are eight times as frequent on goods as on passenger trains, and the very material improvement which has been achieved is clearly due to the gradual replacement of the older wagons. In order of magnitude, the second type of failure is broken rails. There were 352 cases in 1953 and 444 in 1946-1950. A broken rail is a potential cause of a serious accident although no

* *Report to the Minister of Transport and Civil Aviation upon the Accidents which occurred on the Railways of Great Britain during the Year* 1953. H.M. Stationery Office (2*s.* 3*d.* net).

major disaster in 1953 was attributable to this cause.

It has long been the practice to classify accidents as due to either human failure or material failure, although in many cases of the latter human carelessness or oversight had some part. According to the usual classification, however, it is to be recorded that technical defects were responsible for 14·1 per cent. of the total accidents. In view of the fact that 16·4 per cent. were due to misconduct of the public, the technical record is reasonably satisfactory. In conclusion, it should certainly be mentioned that the collision at Stratford on the Central London Line resulting in the death of a passenger. was the first occasion on which a passenger had been killed in the 60 years of London tube-railway operation.

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CONTRACTS

Electric-Arc Melting Furnaces. An order valued at approximately £115,000 for electric melting furnaces has been placed with BIRLEC LTD., Tyburn-road, Erdington, Birmingham 24, by the Tata Locomotive and Engineering Co. Ltd., Jamshedpur, India. The order calls for two four-ton and two seven-ton capacity Lectromelt electric-arc furnaces to be erected, with the ancillary electrical gear, at new foundries at Jamshedpur during the summer of 1955.

Power-Station and Transmission-Line Equipment. Contracts have been placed during the past month by the British Electricity Authority for power-station and transmission-line equipment amounting, in the aggregate, to £2,888,084. The contracts include: for Belvedere power station, Kent: preliminary access works, with JOHN LAING & SON LTD.; for Littlebrook "C" power station, Dartford; a 360,000 lb. per hour boiler, with INTERNATIONAL COMBUSTION LTD.; for Brighton "B" power station: a sewer under Shoreham Harbour, with CHARLES BRAND & SON, LTD., and coal-handling plant, with MITCHELL ENGINEERING, LTD.; for Willington "A" power station, near Derby: instruments and automatic controls, with ELECTROFLO METERS LTD.; for Elland power station, Yorkshire: structural steelwork for boiler house and turbine house, with HEENAN, BEDDOW AND STURMEY, LTD.; for Skelton Grange power station, Leeds: No. 3 cooling tower, with FILM COOLING TOWERS (1925) LTD.; for Wakefield "B" power station, Yorkshire: 11-kV and low-voltage main and auxiliary cables, with DRAKE AND GORHAM (CONTRACTORS) LTD.; for Stella-North power station, Newcastle-upon-Tyne: main and auxiliary cables and accessories, with the LONDON ELECTRICITY BOARD; for Barony power station, Ayr: 33-kV switchgear and accessories, with COOKE AND FERGUSON, LTD., and a 275-kV twin 0·175 sq. in. double-circuit transmission line from Uskmouth to Melksham, with the J. L. EVE CONSTRUCTION CO. LTD.

Marine Diesel Engines. Recent orders received by MIRRLEES, BICKERTON AND DAY, LTD., Stockport, include one for a passenger and cargo vessel building for the West Australian Government, comprising three TL five-cylinder marine auxiliary engines, each developing 262 b.h.p. at 600 r.p.m. to be direct coupled to 150-kW 225-volt direct-current generators supplied by the BRITISH THOMSON-HOUSTON CO. LTD. Another order is for four engines for a cutter dredger being built in a Dutch shipyard for Belgian owners. Two of the engines are JVS 16-cylinder V-form pressure-charged engines, each developing 1,265 b.h.p. at 630 r.p.m. for the main dredging-pump drive. The third engine is a six-cylinder in-line unit, developing 400 b.h.p. at 750 r.p.m., for driving WARD LEONARD generator equipment and the fourth is a three-cylinder in-line engine developing 200 b.h.p. at 750 r.p.m. for driving the ship's generator equipment. Messrs. Mirrlees are also supplying two eight-cylinder 950-b.h.p. engines for propelling a Canadian coastal vessel, and a six-cylinder 697-s.h.p., propelling engine for a Norwegian ferry motorship.

The largest marine contract placed with Messrs. Mirrlees so far this year is an order from Brooke Marine Ltd., Lowestoft, for 20 propulsion and 20 auxiliary engines. These will be installed in 20 trawlers each 188 ft. 9 in. in overall length intended for service in the White Sea and other North European waters. The propulsion units are KSDM eight-cylinder direct-reversing pressure-charged engines, each developing 1,100 s.h.p. at 200 r.p.m. The auxiliaries are JS four-cylinder pressure-charged in-line engines, each developing 380 b.h.p. at 750 r.p.m., for trawl-winch duties.

BOOK REVIEWS

Temperature Measurement in Engineering, Vol. I. by H. DEAN BAKER, E. A. RYDER and N. H. BAKER. *John Wiley and Sons, Incorporated, 440 Fourth-avenue, New York 16, N.Y., U.S.A.* (3·75 dols.); and *Chapman and Hall, Limited, 37 Essex-street, London, W.C.2.* (30*s*.)

The authors' object in preparing this two-volume work on temperature measurement is to provide, in non-mathematical terms, information in the particular forms needed by the engineer. They state that, in contrast to previously published books, stress is laid upon specific procedures and techniques.

Only Volume I is at present available. The first four of the thirteen chapters of this are introductory to both volumes. Eight chapters then deal with thermocouple applications in solid bodies within the medium-temperature range. A short final chapter summaries the contents of this first Volume. Thus it will not be until Volume II is available that temperature measurements in the very high and very low ranges will be discussed, nor the important matters of accurate surface temperature measurements and of the measurement of rapidly changing temperatures. In general, techniques other than those associated with thermocouples are similarly held over until Volume II. It is to be hoped that the second volume will not be long delayed. In the meantime it may be remembered that British Standard Specification No. 1041, 1943, "Code for Temperature Measurement," exists and that it surveys the whole field of temperature measurement in some 70 pages in quarto size.

The introductory four chapters of the book give an up-to-date summary of modern temperature scales. There is an adequate discussion of the International Temperature Scale of 1948, including reference to the triple-point water cell and to the benzoic acid cell as well as to other more widely known fixed temperature points. This section includes what the authors call "shop standards" and a discussion of modern mercury-in-glass thermometers of different qualities, with various sources of error. Brief descriptive treatments of a range of other well-known temperature-measuring devices such as gas thermometers, vapour pressure thermometers, radiation pyrometers, electrical resistance thermometers and bimetal strip thermometers then follow, but less well-known temperature indicators such as crayons, pellets, paints, infra-red photography and sound velocity methods are also included. Full lists of references to further sources of information are given and there is no doubt that this section will be of much interest to the engineer. The authors proceed to discuss usefully the planning of suitable temperature-measuring methods as part of an assumed research project and discuss briefly the nature and treatment of errors. This part of their work is perhaps too brief, and the list of writings by other authors is very short. The general introductory chapters conclude with a short superficial discussion of specially difficult conditions, such as those of movement and vibration, under which engineering temperature measurements may have to be made.

Chapters 5 to 12, which contain the main engineering part of the book, begin with a review of straightforward thermocouple circuit theory, with useful, though untabulated, practical figures on performance of various wires in combination, but plain "normal accuracy" rather than "ultimate precision" is in mind. The practical details of couple construction are well described and an adequate bibliography is provided. The brief chapter which follows on instrumentation with thermocouples fails to cover sufficiently the characteristics of galvanometers and amplifiers, which can be of decisive importance in this work. The chapter upon design calculations which follows gives various formulæ for such sources of error as loss by heat conduction along the couple leads, but it would have been improved by more numerical calculations. Chapters on the methods of installing couples in solid bodies for measurements deep down, near the surface and so on, are of value in stimulating thought on practical details and are supported by an extensive bibliography. However, information on drills and drilling machines could have been safely left to the engineers for whom the book is intended.

Much of the remaining information given in this volume is of a workshop character. Useful facts are included concerning protective coatings, heat- and corrosion-resistant metals, plastics, refractories and cements. Volume I concludes with another practical chapter on couple installation to record temperature gradients. In general this book is a useful addition to an engineer's bookshelves.

Theory of Machines. By BEVIS BRUNEL LOW. *Longmans, Green and Company, Limited, 6 and 7 Clifford-street, London, W.1.* (25*s*.)

In preparing a text-book on the theory of machines, an author has a wide choice of material at his disposal for the purpose of explaining mechanical movements in terms of simple mathematics and mechanics. The aim is not to describe a large number of different devices, but rather to select those of fundamental importance and study their motions when combined in certain definite ways. Further, it is essential to develop the subject so as to facilitate the student's discovery that any mechanism, however complicated, can be resolved into groups of more elementary combinations. In his book, Mr. Low performs this task by considering the relevant principles in such a manner as to emphasise their practical significance and relationship and, at the same time, make them a matter of intelligent interest to the reader, up to the standard required in most universities and in the leading engineering institutions.

The book consists of the greater part of the author's earlier work entitled *Engineering Mechanics*, which was first published in 1942, together with eight additional chapters. It is an advantage to have the elements of mechanics explained in detail at the outset, as here, to obviate as far as possible the disconcerting necessity of reverting to elementary topics when the reader's attention should be devoted to the more advanced question of mechanism. Perusal of the text shows that the arrangement also makes for clarity in the exposition of the kinematics of machines, as, for instance, the analysis of motion cams, belt and rope drives, toothed gearing, and gear trains, including a semi-graphical treatment of epicyclic gears which is not perhaps so widely known as it should be. The same may be said of the subsequent development of the dynamics of machinery, in chapters under the heading of friction, turning moments and flywheels, balancing, and vibrations.

The author would seem to believe that a student's college text on this subject should find a permanent place in his professional library, as he will feel greater confidence in consulting a book with which he has become familiar at college than one entirely new. The reason is that some sections cover much more ground than is customary in a book of this class, while others contain novel applications of the kind likely to be encountered in practice, as may be indicated by reference to the chapter on brakes and dynamometers, where the theory has been exemplified in the case of a brake fitted with pivoted shoes of the external-contracting type.

Those who are not especially proficient in mathematics will doubtless appreciate the inclusion of proofs of the chief theorems and formulæ, as well as the worked-out examples in the text, and the answers to a comprehensive collection of exercises for solution on the part of the reader. In a future edition, space should be found for an adequate analysis of Hooke's joint, and the opportunity should then be taken to include Professor W. J. Duncan's book on the theory of dimensions in the useful bibliographical notes which have been placed at the end of certain chapters.

BOOKS RECEIVED

Some of the books noticed in the Books Received column are selected for extended review in later issues of ENGINEERING.

Plant Engineer's Easy Problem Solver. By LOUIS J. MURPHY. *Conover-Mast Publications, Incorporated,* 205 *East-42nd-street, New York* 17, *N.Y., U.S.A.* (6 dols.); and *Bailey Brothers and Swinfen, Limited,* 46 *St. Giles High-street, London, W.C.*2. (48*s.*)

This book takes the form of examples and solutions with accompanying nomographs and charts. The subjects covered include pumping, metal working, mechanical power transmission, heating and ventilating, compressed air, materials handling, internal-combustion engines and industrial-waste treatment.

National Building Code of Canada, 1953. *National Research Council of Canada, Scientific Liaison Office, Africa House, Kingsway, London, W.C.*2. (23*s.*)

The code consists of eight parts dealing with different aspects of building and civil engineering, e.g., General Administration, Climatic Variations, Design, Materials and Services. Some of the parts are subdivided and in all the code comprises 15 sections. Design, for example, includes sections on foundations, wood, unit masonry, plain concrete, reinforced concrete, steel and cladding. The code is solely an advisory document having no legal status unless specifically adopted by an authority. It does give, however, the minimum acceptable regulations respecting public health, fire protection and structural sufficiency for use throughout Canada.

Sound Absorbent Treatments. Building Research Station Digest No. 36 (Revised). *H.M. Stationery Office, Kingsway, London, W.C.*2. (3*d.*)

The quality of the sound in a room or building depends on the reverberation period which is sustained after the initial sounding time, and the reverberation period is determined by the absorbent qualities and distribution of the different surface finishes in the room. The digest briefly lists the materials available, giving their qualities and some practical considerations on methods of fixing.

Report on the Derailment which occurred on January 27, 1954, between Speke Junction and Ditton, in the London Midland Region, British Railways. Ministry of Transport and Civil Aviation, Railway Accidents. *H.M. Stationery Office, Kingsway, London, W.C.*2. (6*d.*)

The conclusion of the Board of Inquiry was that the accident happened as a result of the failure of a trunnion on a vacuum-cylinder assembly on a wagon of the freight train. Incorrect machining of a non-standard type of trunnion created the conditions in which a flaw developed, and eventually caused it to break.

Protection against Radiations from Radium, Cobalt-60, and Cesium-137. U.S. National Bureau of Standards Handbook 54. *The Superintendent of Documents, U.S. Government Printing Office, Washington* 25, *D.C., U.S.A.* (25 cents.)

With the increasing use of radioactive isotopes by industry, the medical profession, and research laboratories, it is essential that certain basic precautions be taken to protect the user and the public. The recommendations contained in this handbook represent what is believed to be the best available opinions on the subject to date.

The Machine Tool Trades Association of Great Britain: A Guide to its Members' Activities. *The Machine Tool Trades Association, Victoria House, Southampton-row, London, W.C.*1. (Free on application.)

This booklet is divided into three sections. The first consists of an alphabetical list of manufacturers followed by indexes relating to metal-cutting and forming machine tools, small tools, measuring instruments and equipment, woodworking machinery, and ancillary equipment. The second section lists selling organisations in the Association, and the third section is concerned with British importers handling the products of foreign manufacturers in the United Kingdom.

Irons, Hot Plates and Space Heaters (Electrically-Operated). U.S. Case Study Data on Productivity and Factory Performance. Prepared for the Foreign Operations Administration, Industrial and Technical Assistance Division, by the United States Department of Labor. Distributed in Great Britain by the *British Institute of Management, Management House,* 8 *Hill-street, London, W.*1. (7*s.* 6*d.*)

This is a further issue in the series of Case Reports designed to give managements in this country an opportunity to compare their own performance with that of similar plants in the United States. The report gives direct and indirect man-hours per operation and/or per unit of product, illustrated by plant and product characteristics, as well as descriptions and illustrations of work flow, material handling, shop layout, standardisation, inspection and production control. A glossary of trade and technical terms completes the report.

B.B.C. Handbook, 1955. *British Broadcasting Corporation, Broadcasting House, London, W.*1. (5*s.*)

This is a new B.B.C. publication, being planned on somewhat different lines from the earlier handbooks or year books. It covers the constitution of the B.B.C., the broadcasting services, the programmes and programme departments, a review of the year, and a section is devoted to supplementary details including schools broadcasts, staff, reception problems, programme service costs, and a list of B.B.C. publications.

Electricity Undertakings in Natal. Natal Regional Survey, Volume 5. Published for the University of Natal, by *Oxford University Press* (*Geoffrey Cumberlege*), *Amen House, Warwick-square, London, E.C.*4. (25*s.*)

The purpose of this report is to give a general survey of the economic aspects of electricity generation, transmission and distribution, with special reference to Natal, and to give technical and financial data relating to established electricity undertakings and supply authorities in Natal. The book is illustrated with photographs, maps and graphs.

Catalogue of the Scott Collection of Books, Manuscripts, Prints and Drawings. Compiled by BETTY M. COOPER. *The Institution of Naval Architects,* 10 *Upper Belgrave-street, London, S.W.*1. (42*s.*)

The Scott Library was founded by John Scott, who was born in 1830, and came from a famous family of Scottish shipbuilders. In 1930 the Library was presented to the Institution of Naval Architects, where it now occupies a separate room. This catalogue is divided into sections covering printed books, manuscripts, and prints and drawings, the section on books being classified according to the century of publication. A bibliography, and author, title and subject indexes are included.

Building: The Evolution of an Industry. By P. MORTON SHAND. *Token Construction Company, Limited,* 68 *Mount-street, London, W.*1. (15*s.*)

An historical survey of the building industry, with drawings by Charles Mozley. The progressive evolution of building in stone, cement and concrete, brick, and iron and steel is discussed, and there are chapters on roofing, windows, chimneys, stairs, doors and shutters, and tools and plant. The book concludes with a chapter on the history of building organisation.

Bibliography of Traffic Engineering Literature. Compiled by KATHRYN CHILDS CASSIDY and CELE KAGAN. *Bureau of Highway Traffic, Yale University, New Haven, Connecticut, U.S.A.* (Free on application.)

This bibliography is intended primarily for the use of traffic engineers or technically-trained personnel working in the field of traffic operation and control. The emphasis is on engineering but some articles are included on administrative, educational and "enforcement" problems and methods.

Nuclear Reactors for Industry and Universities. Edited by ERNEST H. WAKEFIELD. *Instruments Publishing Company,* 845 *Ridge-avenue, Pittsburgh* 12, *Pennsylvania, U.S.A.* (2 dols.)

To aid universities and industries in making decisions concerning the installation of reactors, eight well-known American authorities in the field of nuclear energy have combined to write this book. The basic subjects covered include nuclear reactor types, availability and selection, radioactivity measurement, radiation protection, reactor control, instruments for experimentation, cost study and legal aspects.

Engineering Units and the Stroud Convention. For Students of Applied Mechanics and Engineering Science. By F. W. THORNE and A. C. WALSHAW. *Blackie and Son, Limited,* 17 *Stanhope-street, Glasgow, C.*4. (3*s.* 6*d.*)

The purpose of this booklet is to present a simple method of overcoming difficulties concerning units and dimensions when developing and using formulæ. General analysis has been cut to a minimum in favour of specific cases dealt with in worked examples. The Stroud system is a system for using units of any kind, enabling the arithmetical stage of any problem to be carried out consistently and logically. It has been in use at the Royal Naval College for fifty years.

Engineering Dynamics. Volume III: Steam Turbines; Volume IV: Internal-Combustion Engines. By C. B. BIEZENO and R. GRAMMEL. *Blackie and Son, Limited,* 17 *Stanhope-street, Glasgow, C.*4. (Volume III, 40*s.*; volume IV, 50*s.*)

The more difficult problems encountered in engineering practice are normally omitted from standard text-books on the subject owing to lack of space or time. This book is intended to remedy that deficiency, and the subject matter is comparable to that covered by the special lectures to post-graduates, now provided by most technical colleges. The authors have suggested that an alternative title might be "Engineering Mechanics for Post-graduates." Importance is attached to numerical results, but prominence is given to methods of solution, one chapter being devoted to a study of methods. Volume I, covering theory of elasticity, is to be published in January, 1955, and volume II, covering elastic problems of single machine elements, is to be published in the autumn of 1955.

Radioactive-Waste Disposal in the Ocean. U.S. National Bureau of Standards Handbook 58. *The Superintendent of Documents, U.S. Government Printing Office, Washington* 25, *D.C., U.S.A.* (20 cents.)

Recommendations of the United States National Committee on Radiation Protection for the proper use of this method of disposal of radioactive waste. Information given includes the characteristics of the ocean, the fate of radioactive materials introduced into the ocean, selection of sites, and recommended containers for packaged disposal.

The Physics of Particle Size Analysis. Supplement No. 3 of the "British Journal of Applied Physics." *The Institute of Physics,* 47 *Belgrave-square, London, S.W.*1. (35*s.*)

A collection of papers presented at a Conference at the University of Nottingham, April, 1954. Discussion on the papers is included and there is a comprehensive index. A summary is given at the head of each paper.

Glass Reinforced Plastics. Edited by PHILLIP MORGAN. Published for "British Plastics" by *Iliffe and Sons, Limited, Dorset House, Stamford-street, London, S.E.*1. (35*s.*)

The types of glass fibres used are given, and properties of laminates made from each are compared. The most widely used resin type, the polyester, is described in detail. Moulding techniques used commercially are described, and separate chapters are devoted to mass-production methods and the manufacture of pipe and rod. The chapters on the application of these materials cover the aircraft, electrical, automobile and boat-building industries.

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TRADE PUBLICATIONS

Copies of any of the following trade publications are obtainable from the addresses given, though distribution is sometimes restricted.

Design of Motor-Car Style. AUSTIN MOTOR CO. LTD., Longbridge, Birmingham. Stages in "styling" the company's new "Cambridge" motor-car, from the artist's first sketches, through coloured drawings, practical design considerations, making several quarter-scale models in clay (each with detail variations in style), the final selection, drawing to full size, building a full-size clay model on a wooden frame, building several prototype bodies from manually-beaten panels, to the making of the dies, the final checks, and so to production. A handsome booklet in full colour with brief explanatory notes.

Hard-Facing Alloys. WALL COLMONOY (CANADA) LTD., BRITISH BRANCH, Carfin Industrial Estate, Holytown, Motherwell, Lanarkshire. Hard-facing alloys available in various forms: rods for oxy-acetylene welding, electrodes, paste, powder, wire and castings. The alloys contain chromium borides which impart to the material its properties of increased resistance to abrasion, corrosion and oxidation. General catalogue giving characteristics and properties of the alloys and typical industrial applications.

Tungsten and Molybdenum Products. ELECTRO-ALLOYS LTD., 47 Brunel-road, Acton, London, W.3. Makers of electrical contact rivets and screws faced with tungsten, lead-in wires for glass-to-metal seals, tungsten electrodes for arc welding in inert-gas atmospheres, rotating tungsten anodes for X-ray valves, and various other components made from molybdenum and tungsten. Catalogue giving illustrated descriptions of the above products in English, French and German.

Aluminium Information. ALUMINIUM DEVELOPMENT ASSOCIATION, 33 Grosvenor-street, London, W.1. List of publications—bulletins, brochures, research reports, reprints, general publications. List of 16-mm. sound films, 35-mm. film strips, and wall charts. Two catalogues.

Plating Barrels. W. CANNING & CO. LTD., Great Hampton-street, Birmingham 18. Typhon plating barrels in three solution capacities, from 7 pints to 10 gallons. Illustrated leaflet.

The Institution of Naval Architects Autumn Meeting (continued from page 522)

THE MEASUREMENT OF POWER

THE USE OF TORSIONMETERS IN MARINE DYNAMOMETRY

The first of the two papers presented at the second technical session during the Autumn Meeting of the Institution of Naval Architects was by Dr. T. W. F. Brown and dealt with "The Measurement of Power." The chair was taken by Mr. R. B. Shepheard, C.B.E., B.Sc., Chairman of the Council.

There were, said Dr. Brown, two main methods of measuring power: by absorption of the power in a brake or dynamometer or, where no power was absorbed, either by measuring the torque and the revolutions at some point in the mechanism or by measuring the propeller thrust and the speed of the vessel. The earliest form of absorption dynamometer was the friction brake devised by Piobert and Fardy in 1821 and applied to engine testing by Prony. Froude, Kelvin and others had interested themselves in the subject, but the main difficulty with all such devices was that the power which could be absorbed was very limited. In the measurement of power by the use of a hydraulic dynamometer, the work of Froude was classic. At the request of the Admiralty, he designed one to measure 2,000 h.p. but did not live to see it tested; it was applied in 1880 to the screw shaft of H.M.S. Conquest and was fully described at the time in ENGINEERING (vol. 29, 1880). The hydraulic dynamometer was at its best in slow-speed work.

HYDRAULIC AND ELECTRICAL METHODS

So far, it had not been possible to construct a torsionmeter with an accuracy better than ± 2 per cent., whereas the ideal torquemeter should have an accuracy of ± 0·25 to 0·5 per cent. It should be easy to fit into the line shafting and should measure an average torque integrated over a period many times longer than the period of any cyclic variation that might occur. Most torquemeters relied on the measurement of twist in the shaft, which was a very small quantity. The turning moment in the shaft, however, was a large quantity and it could be that direct measurement of that larger quantity might give greater accuracy. The hydraulic torsionmeter gave the most direct measurement of torque. It was suggested that the best results would be achieved by mounting the torsionmeter on a special short length of shaft, calibrated for a range of torques, which could be replaced by a normal mild-steel shaft after the trials were completed. Torsionmeters in which brushes had to operate against slip rings running at high surface speeds should be avoided; but slip rings running at low surface speeds were satisfactory if the effect of variations in contact resistance could be avoided. With the improvement in electrical components the measurement of torque by electrical means appeared to be the most accurate at the present time, where the complexity of installing a hydraulic torquemeter and pump could not be justified. It seemed that the integrating power meter might be developed into a robust and useful instrument, likely to meet all service requirements.

The discussion was opened by Mr. F. H. J. Yearling, who observed that the Froude brake illustrated in the paper, or a similar apparatus, was used at Torquay in 1873 and was transferred to Haslar and used there until 1939, i.e., for a period of 66 years; a remarkable tribute to Froude as an engineer and to the makers of the apparatus. A further instance of Froude's genius was the hydraulic brake, the prototype of which he (Mr. Yearling) exhibited. Apparently, very little had been done to measure the frictional losses in shafts since 1880, in the experiments on the Conquest, and he thought that the time had come to make such experiments again. Dr. Brown had stated that he expected an accuracy of ± 2 per cent. in a torsionmeter. That was rather surprising; his own experience on ship trials suggested that it was more like ± 5 per cent. or even worse. It was also suggested that a long length of shaft should be used. He did not think that was feasible, however; such a long power shaft was not usually available.

Dr. Ir. J. D. van Manen said that reliable measurements with torsionmeters were of the utmost importance for determining the allowances required to bring trial-trip and service results into agreement with the results of the model test, and Dr. Brown's experience would be very useful to those who were trying to improve the accuracy of torsionmeter results. It might be of interest if he gave some information on the experience of the Netherlands Ship-Model Basin with the Maihak type of torsionmeter. When measuring the torque by means of oscillating test wires, the wires were applied two at a time. One wire was loaded and the other unloaded by the torsion angle of the shaft; thus the influence of temperature and centrifugal forces were eliminated. As the principle of the Maihak torsionmeter was based on the measurement of a frequency developed in the test wires, variations in line voltage or in switch contact resistance did not affect the performance of the torsionmeter. As to the difficulty of observation of the Maihak torsionmeter during cyclic variations in torque, the experience of the N.S.M.B. was that sufficient accuracy was possible on single-screw ships. To prevent inaccuracies caused by zero wander, it was strongly recommended that the zero point be controlled as much as possible. For further observations in a seaway it was important to register or integrate the power measurements without decreasing the accuracy of measurement. In that connection he would mention the Japanese paper "An Investigation into the Seagoing Qualities of the Single-screw Cargo Ship Nissei Maru by Actual and Model Ship Experiments," prepared for the Seventh International Tank Conference. In his opinion, in many cases the value of the results obtained with a given torsionmeter depended more on the skill and experience of its operator than on its type.

TORSIONMETER FOR SHIP TRIALS

Dr. J. F. Allan remarked that the National Physical Laboratory's type of torsionmeter, which was mentioned in the paper, was designed as a laboratory instrument to be fitted for use on trials, and under expert supervision. The unit had been used for 16-in. to 48-in. shafts without modification and could be adapted for use over ranges of other sizes of shafts. The accuracy of the instrument was at least equal to that of the Siemens-Ford torsionmeter, and it had the added advantage that it could be calibrated accurately in the laboratory, both before and after the trials. A device was built into the system so that accurate revolutions were maintained as necessary during trials. The modulus of rigidity of the shaft was of importance in the N.P.L. type of torsionmeter, and recent experience made it clear that to calibrate the torsionmeter on the shaft was absolutely essential for accurate results. The system of calibrating on the ship which Dr. Brown had indicated was interesting. The proposal that Dr. Brown made, of dealing with 6-ft. lengths of shaft, was attractive, but the figures suggested that it might be difficult to do that on a ship, partly because of the difficulty of finding space. Further, there was a great practical difficulty, during commercial trials, in fitting special lengths of shaft which had to be calibrated.

Mr. A. Silverleaf, referring to the work in the Ship Division of the N.P.L. in measuring power, said that, while the Division had a considerable interest in power measurements on shipboard, their principal concern was with the measurement of power delivered to, and the thrust delivered by, model propellers, driven alone or in conjunction with the hull. The problem was very different in degree from that discussed by Dr. Brown, but it was precisely the same kind of problem, and presented in addition the particular difficulty that they must make measurements over the full range from zero to full load, if that was possible. The main problem, since there was always a screw to absorb the power, was the development and use of accurate transmission dynamometers. In the past few years they had designed and constructed new instruments for those experiments. For internal drive, the torque was measured by stator friction reaction. It was proposed still to measure thrust through linkages, using springs, and the hydraulic pick-up for force measurement. They had found that the best solution to their problem was to use the electrical torsionmeter incorporated in the large ship torsionmeter. They were also measuring thrust, rather unusually, by an inductance strain-gauge system.

INTEGRATING POWER METER

Electrical methods had very considerable advantages, but there were also difficulties where measurements were being made over the range from zero to full load. To measure power, it was essential to measure revolutions accurately, and in the N.P.L. they were using high-speed mechanical meters or electronic meters. The Yates integrating power meter was a most interesting device. Had those concerned considered the adoption of magnetic means instead of using the tooth wheel to generate the impulses?

Professor E. V. Telfer said that all would deplore the recent death of Mr. Yates. In connection with the Yates power meter, was Dr. Brown aware of what appeared to be an identical arrangement which was invented some 20 years ago by the late Mr. Gerald Whiting, a former Member of Council of the Institution? He (Dr. Telfer) had tested several of Mr. Whiting's instruments on ships against his own generalised power diagram and was surprised to find how closely the integrating power-meter results and the analysed results agreed over weeks and even years.

Dr. S. Livingston Smith, C.B.E., emphasised that there were two distinct problems to consider. One was to measure the power in models and in the shops on shore, and the other to measure the power in the actual ship. With models and in the shops the problem was relatively simple, because the shaft could be cut and therefore it was possible to measure the actual power being transmitted between one portion and the other. But no shipowner or shipbuilder, nor Lloyd's Register, would think of cutting the shaft in the ship so that it was necessary to measure the power being transmitted through the whole length of the shaft. The B.S.R.A. had tackled that problem because they knew that they would have to measure power on ships' trials, and their findings were published in Mr. R. Cook's paper to the Institute of Marine Engineers, to which Dr. Brown had referred. They began by trying all the types of torsionmeter available, and concluded that the only way to proceed was to measure the actual torsion in the shaft. They developed torsionmeters for that purpose and used the one which seemed to have the greatest promise. We tested that particular torsionmeter on trials, measuring the power from a Diesel engine with known criticals, the torsionmeter being placed on a shaft coupled to a Froude brake. The torsionmeter was all right to about ± 2 per cent., provided that the stresses and strains in the shaft were sufficiently high to be measured with that accuracy. Assuming that a torsionmeter is accurate to within ½ per cent., it was still necessary to calibrate the shafting: but the shipowner had to get his ships to sea

and it was frequently difficult to persuade him to hold things up for a sufficient time to get the shafting calibrated. Again, there was the problem of the modulus of rigidity; he was not altogether satisfied that, in their original tests, when they took a figure of 11·95 million, they were right to ½ per cent. He believed that, as Dr. Brown had indicated, far less was known about the properties of mild steel than about alloy steels, and it was conceivable that, after forging, the modulus of rigidity might not be 11·95 million. They had studied shaft losses and were endeavouring to get some figures for them; they appeared to be about 3 per cent.

Sir Maurice E. Denny, Bt., recalled that the torsionmeter devised by the late Mr. Yates was, in essence, the same as one tried by his own firm about 40 years ago. They measured the torque over a long length of shaft by electrical means, the impulses being received in an ear microphone. When the apparatus was at zero and there was no torque, they heard what sounded like a single click; displacement of one of the magnets transmitted a double click. By a suitable micrometric adjustment they could bring it back to one click and could measure the amount of adjustment necessary to do so. A difficulty was to attach the apparatus to a ship's structure, which was elastic. Rolling or pitching or vibration, or a change in the loading of the ship, would affect the structure and then the two points were no longer in the same identical relation as when the apparatus was at zero.

AUTHOR'S REPLY

Dr. Brown, replying to the discussion, said that Mr. Yearling had suggested that to have a torsionmeter of an accuracy of ± 2 per cent. on ship trials was better than in his experience. The paper was an attempt to show some possible lines on which to improve that figure. Reference was made to measurements on a long length of shaft and to the idea that his late colleague, Mr. Yates, had introduced. That instrument could be set to zero very easily because, instead of a toothed wheel, there was a coil for a second timing pulse, which maintained a better frequency. With regard to fluctuations, the method of overcoming their effect was fairly easy. Instead of having only two permanent magnets, a further pair could be inserted and the results averaged out. The effects of torsional oscillations, and of the bending and twisting of the ship, could be avoided by averaging the movement. The integrating power meter was, of course, the best of all, because it averaged over any interval of time. He was interested in the further information on the Maihak torsionmeter given by Dr. van Manen. He touched upon the main difficulty with torsionmeters when he said that the value of the results depended on the skill and experience of the operator. In scientific work of the order of accuracy they were trying to achieve, that was one of the things that must be eliminated. Mr. Silverleaf discussed the improvement of torsionmeters and thrust meters. They hardly ever measured thrust by capacitance gauges; there were so many errors due to changes in dielectrics. The only reason why he obtained very high accuracy with magnetic reluctance torsionmeters was because they were working on a small scale, whereas the paper attempted to deal with the measurement of high powers. He agreed with everything Dr. Livingston Smith had said. If power had to be measured in a ship without providing a special shaft or if it was not practicable to cut the shaft and interpose a transmission dynamometer, the only course was to measure the twist in the shaft. In measuring the twist in the shaft it was necessary to use either a short-length torsionmeter which could be moved from shaft to shaft, or to use a long length of shafting, which still had to be calibrated, though it might be more accurate because there was a large twist between the two measuring points. He had tried to indicate a method of eliminating the relative movement of those zeros over a long length by having a calibrating signal.

To be continued

INTERNAL-COMBUSTION ENGINE RESEARCH

B.I.C.E.R.A'S ELEVENTH ANNUAL REPORT

The eleventh annual report of the British Internal Combustion Engine Research Association (Bicera), Slough Trading Estate, Buckinghamshire, has recently been published. The period covered is April 1, 1953, to March 31, 1954.

The programme of work for the year is generally decided by the Research Committee in conjunction with the advice of a particular panel. At present, a panel exists for each of the following subjects: torsional vibration; pressure-charging; noise; combustion, fuels and lubricants; stress analysis; and gas turbine work. There is also a general research section which is concerned with fuel-injection, fuel ratings, piston cooling and the development of instruments.

The Bicera method of crankshaft stiffness evaluation has, as a result of tests on shafts of over sixty engines, been recommended as the most accurate available. Investigations have been made to determine the effect of harmonic components of changes in injection timing on shafts. Much of the work towards a handbook in the course of preparation on the subject of torsional vibration has been completed.

Tests on Roots-type pressure chargers were completed and a report has been issued containing comparisons of design, performance and noise. In addition to the eight Roots-type machines, two Lysholm and two Bicera compressors were included in the survey. A Bicera compressor for 340 cub. ft. per minute has been tested on a four-cylinder four-stroke engine and it was found that the output of the engine was increased by 50 per cent. The minimum specific fuel consumption decreased by 5 per cent. and the boost pressure was 7·4 lb. per square inch. Tests on an 850 cub. ft. per minute machine showed it to be much quieter than a Roots-type at high speeds.

The experimental pressure charging of the Mirrlees TL3 engine proceeded during the year to the full extent consistent with the capability of the engine of withstanding the high working pressures involved, without reducing the compression ratio below the minimum that would enable the engine to start and to run at light load. To permit the work to proceed further, avoiding these limitations, the Bicera variable-ratio piston was devised. The piston provides a high compression ratio at starting and light loads, and a progressively diminishing ratio at loads above that at which the maximum pressures reached a pre-determined value. When the engine was fitted with these pistons the maximum pressure in the three cylinders was practically constant at all loads above 100 lb. per square inch. Examination of the pistons after 240 hours' running at loads up to 200 lb. per square inch b.m.e.p. revealed a satisfactory condition. The high ratio gave improved starting and light-load running, with some improvement in fuel consumption. The turbo-charger at present available does not provide sufficient boost for outputs much in excess of 200 lb. per square inch b.m.e.p. Steps have been taken to provide a turbo-charger which will permit exploitation of the lower compression ratios available with the new piston.

Everything possible is being done, the report states, to ensure that engine noise is made as low as possible. Valve-gear noise is being investigated and it has already been observed that cams of varying designs make very little difference. Combustion noise has also been studied.

INFRA-RED STUDY OF COMBUSTION

A method of examining the distribution of fuel in a combustion chamber has been developed, using a swirl-chamber engine, and a study of the infra-red radiation emitted during combustion in an oil engine has commenced. Spectra corresponding to various phases in the combustion, the first of their kind, have been recorded. They give information of the changing composition of the chamber contents and permit a more accurate assessment of temperature.

With the object of prescribing means of enabling high-speed engines to withstand the destructive effects of low-grade fuels, seven test engines have added 10,500 hours running to the 23,000 hours previously devoted to this investigation. In these tests the engines, fitted with various types of piston rings, grooves, liners and valve seats, are submitted to 500-hour and 1,000-hour tests using a specially blended fuel which is as harmful as any class-B fuel likely to be available. Tests are normally carried out at full power. A number of other tests, however, have been made with variable loading and at light load.

The gas-turbine panel has prepared a report for the Research Committee on developments which have taken place during the year in this special field.

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EXPERIENCES IN ENGINE RESEARCH

Mr. J. H. Pitchford's Address

Giving the Chairman's address to the Automobile Division of the Institution of Mechanical Engineers, Mr. J. H. Pitchford, recalled his long association with Ricardo and Company (1927), Limited, and the development in internal-combustion engines that had taken place in that time. The address was delivered at the Institution on October 5 and is being given also at certain Centres of the Division.

When first joining the firm the problems of combustion in petrol engines were uppermost in mind. After these, he said, came the idea of the high-speed Diesel, an idea which was still being developed. Problems of injection were encountered, and also of cold starting. A vacuum governor followed, and then the sleeve-valve engines, which were installed in medium tanks.

Mr. Pitchford paid tribute to members of the Royal Dutch and Shell groups who had co-operated in research on additives and combustion theory from which much useful knowledge had come. He then went on to consider the developments that took place in combustion chambers, leading to the production of the Comet III head which had proved successful over many years. Other problems he mentioned in actual design concerned adequate cooling arrangements for all parts and the development of bearings capable of taking the shock loading encountered in the Diesel engine.

Concurrently with this work was the development of the test apparatus needed to assess the results. At the laboratories, techniques of high-speed photography, of gas-sampling and of temperature measurements had all been introduced. In conclusion, he outlined the uses of a research establishment of the type of Ricardo's, how it operated and how best it could give help to other firms. Behind the team stood the figure of Sir Harry Ricardo, to whom, he said, he owed so much.

(*Editorial comment in Weekly Survey*)

THE REDUCTION OF VIBRATION*

MOUNTING SHIP MACHINERY ON RUBBER UNITS

By J. Nicolaisen, B.SC., A.M.I.MECH.E.

The structure of a ship as a whole and its component parts have innumerable natural frequencies; since the structure has relatively little damping it is important that, as far as possible, precautions are taken to ensure that unnecessary vibration and noise are avoided. Natural rubber has been proved to be an invaluable material for this purpose.

Even if the unit on flexible rubber mountings has one or more natural frequencies coinciding with the rotational speed of the unit, the inherent damping in the rubber is usually sufficient to limit the amplitudes arising from small incidental unbalances. A relatively small deflection may be sufficient to give a good noise insulation for the fairly high-frequency vibrations arising from ball-bearings, magnetic circuit, commutators, hydrodynamic effects, etc.

It is generally possible to arrange the mountings with some degree of symmetry. The calculations are thereby greatly simplified, and it is possible to estimate the effect of errors in the basic data with reasonable accuracy. In fact, in many instances, if the mountings are arranged in such a way that they are evenly loaded, or the deflections of all the mountings are the same, the calculations can be carried out as if the unit was represented by six separate single masses each supported by one spring.

If a mass supported on a spring is given an impulse it will vibrate with a frequency, in cycles per minute, $f = \frac{30}{\pi}\sqrt{\frac{S}{M}}$ where S is the spring constant and M is the mass. It is often convenient to re-write this as $f = \frac{30}{\pi}\sqrt{\frac{g}{d}}$ or $f^2 d = 35{,}200$ where d is the effective deflection in inches of the spring under the dead load of the mass M—that is, the deflection corresponding to the actual dynamic stiffness of the mounting with the actual loading.

The amplitude of movement of the mass of weight W on a spring due to a vibrating force of amplitude F can be found from:

$$X = \frac{F}{S}\,\frac{1}{(1-n^2)} \quad \text{or} \quad X = F\,\frac{d}{W}\,\frac{1}{(1-n^2)},$$

where n is the ratio of the frequency of the applied force to the natural frequency of the system. The expression $\frac{1}{1-n^2}$ is called the magnification factor.

The rubber damping can be described as hysteresis damping, with an energy loss per cycle proportional to the square of the amplitude and independent of the frequency. If the damping force is expressed relative to the spring constant as E.S, the amplitude for a single mass system at resonance becomes

$$X = \frac{F}{S\,E} \quad \text{or} \quad X = F\,\frac{d}{W\,E};$$

that is, the magnification factor at resonance is limited to 1/E.

Thus with a rubber damping of, say 10 per cent. the magnification factor at resonance is ten times.

Although the damping in a system influences the value of the natural frequencies, the amount of damping in rubber is usually not enough to displace them appreciably, and this effect has been neglected in the present discussion. Also, the effect of the damping on the magnification factor has been neglected except as a limiting factor at resonance.

The calculations for, say, a Diesel generator unit can be conveniently divided into four parts as follows: (1) vertical heaving vibrations caused by vertical forces acting through the centre of gravity of the unit; (2) yawing vibrations caused by couples acting in a horizontal plane; (3) rolling vibrations, caused by rolling forces or couples, which can be considered as the combined effect of the rotation around two axes both parallel to the longitudinal axis through the centre of gravity, each rotation being represented by a single mass system; and (4) pitching vibrations caused by pitching forces or couples which can be considered as the combined effect of the rotation around two axes both parallel to the transverse axis through the centre of gravity, with each rotation represented by one mass system.

On the left of Fig. 1 is the end elevation of, say, a Diesel generator unit with mountings spaced a distance B from the centre plane along each side. H is the height of the centre of gravity CG above the centre of reaction CR of the mountings, R is the radius of gyration of the unit around the horozontal longitudinal axis through CG and S/s is the ratio of the vertical stiffness to the horizontal transverse stiffness of the mountings.

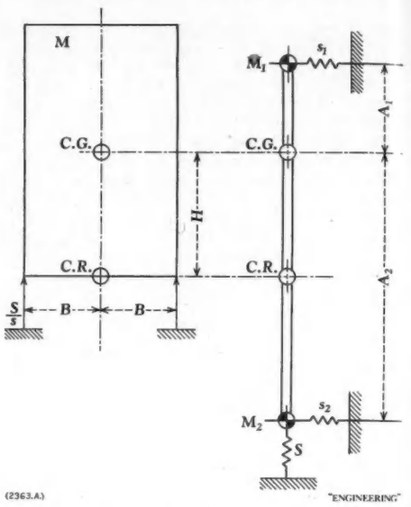


Fig. 1 The diagram on the left represents the end elevation of a Diesel generator unit; its equivalent point-mass system is shown on the right.

EQUIVALENT POINT-MASS SYSTEM

The Diesel generator unit can be represented by an equivalent system, also shown in Fig. 1, consisting of two point masses, M_1 and M_2, which are joined together with a massless rod. The conditions which have to be satisfied by the new system are that the total mass, moment of inertia, vertical and transverse stiffness, and the location of CG and CR are the same as for the original system.

A horizontal force acting on either M_1 or M_2 respectively will produce a horizontal vibration of the mass only to which it is applied, and the movement caused can be considered as a rotation around the other point mass M_2 or M_1 respectively. Thus the rolling vibrating movements can be represented by the sum of the movements of two single mass systems. By resolving the actual rolling forces and couples into horizontal components acting on the two masses, the resulting movements of M_1 and M_2 can be calculated,

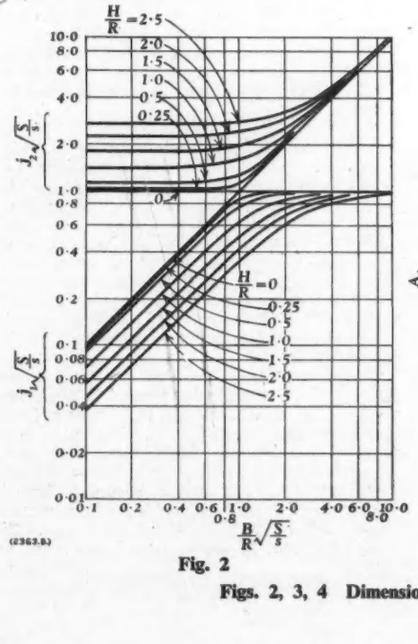


Fig. 2

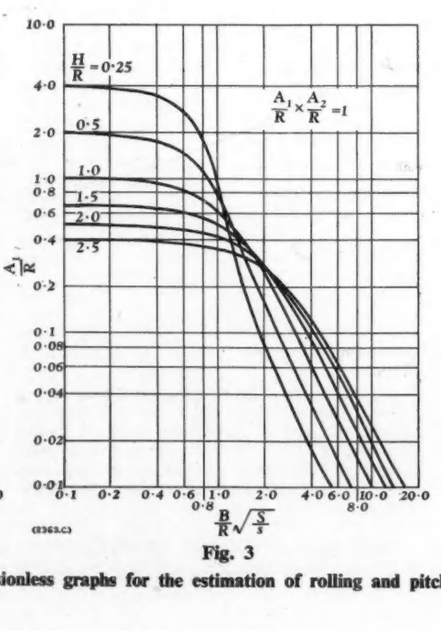


Fig. 3

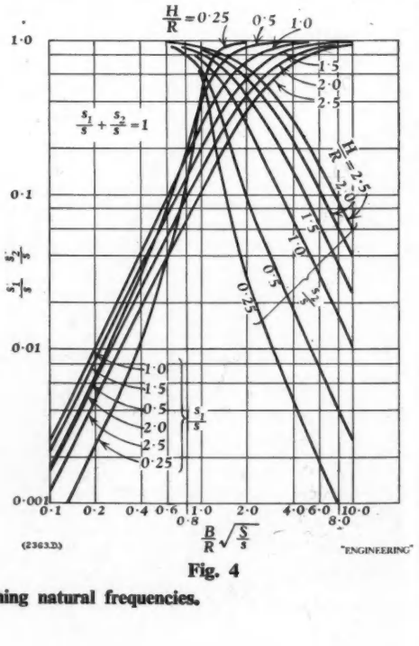


Fig. 4

Figs. 2, 3, 4 Dimensionless graphs for the estimation of rolling and pitching natural frequencies.

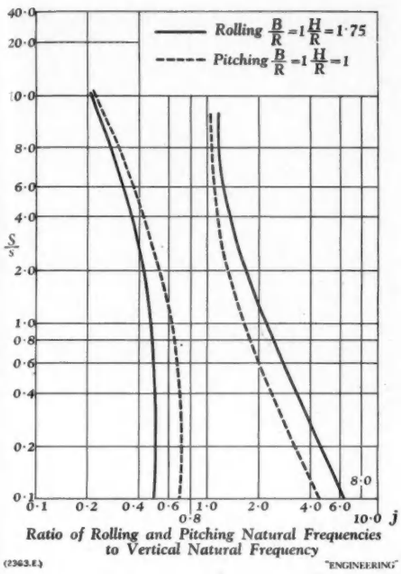


Fig. 5 Graph showing relative rolling and pitching natural frequencies as a function of the ratio of vertical stiffness to horizontal transverse stiffness of the mountings.

and by vector summation the movement at any one point on the cross section of the unit can be found.

Exactly as for rolling vibrations, the pitching vibrations can also be represented by the movements of two single mass systems. However, as a large number of flexible units may be employed along each side of the unit, it is necessary first to work out B as the root-mean-square value of the spacing of the mountings.

To facilitate estimates of rolling and pitching natural frequencies and rolling and pitching vibrating movements, the graphs shown in Figs. 2, 3 and 4 have been prepared.

The values employed in plotting these graphs are dimensionless, i.e., S/s is the ratio of the vertical to the transverse stiffness of the mountings in the rolling and pitching direction respectively, B/R the ratio of equivalent mounting spacing to radius of gyration in the rolling or pitching direction respectively, H/R the ratio of the height of CG above CR to the radius of gyration in the rolling or pitching direction respectively, and j the ratio of the rolling and pitching natural frequencies to the vertical heaving natural frequency of the unit on the mountings.

A_1/R and A_2/R are the ratios of the distances of the equivalent masses M_1 and M_2 from the centre of gravity CG to the radius of gyration, and s_1/s and s_2/s the ratios of the equivalent horizontal spring constants acting on the equivalent masses M_1 and M_2, to the total transverse stiffness of the mountings.

Usually the softer a mounting is, the better noise insulation it provides, but a too-soft mounting arrangement may cause excessive movement of the unit from rolling of the ship, or large-vibration amplitudes from low-frequency unbalanced forces, which may be large compared with the weight of the unit.

However, in many cases appreciable improvements can be gained by the use of relatively low-deflection units.

LOW-DEFLECTION MOUNTINGS

As an example, consider the case of a six-cylinder 600 r.p.m. four-stroke Diesel generator, weighing say 10 to 30 tons, mounted on a typical "rigid" seating. The vibrations would be due mainly to the major torque harmonics of 3rd, 6th and 9th order, or 1,800, 3,600 and 5,400 cycles per minute. Assume $\frac{S}{s}=1$, $\frac{B}{R}=1$ and $\frac{H}{R}=1{\cdot}75$ for rolling vibrations. These figures would give two rolling natural frequencies which, compared with the vertical natural frequency, would be 0·5 and 2. If the "rigid" seating has an equivalent deflection under the dead load of the unit of 0·003 in., this will give a vertical natural frequency of about 3,500 c.p.m. Thus there will probably be rolling resonance for the third- and possibly the twelfth-order torque harmonics, and owing to the low damping of the steel structure, it is possible that very unpleasant vibrations may result.

If, for this same unit, rubber flexible units with a static deflection under the dead load of, say, 0·02 in. were employed, and making an allowance for the dynamic stiffening of the rubber, the natural frequencies would probably be about 1,750 c.p.m. vertically, and 900 and 3,500 c.p.m. for rolling. The sixth-order torque harmonic would probably give rolling resonance at 3,600 c.p.m., but compared with the third-order resonance in the case where the unit was "rigidly" mounted, the couple is very much smaller, and the damping effect of the rubber could be expected to limit the transmission of the sixth-order vibration.

H is usually determined by the given dimensions of the unit. B can usually be varied to some extent, particularly for pitching vibrations. By making a provisional selection of the mounting locations, it is possible to plot a graph, as shown in Fig. 5, giving the relative rolling and pitching natural frequencies of the unit as a function of S/s, from which graphs the values of S/s and the vertical deflection which will give the best possible margin against troublesome resonance can be selected.

After a provisional selection of mountings and their location has been made, a check can be made on the influences of probable errors in the basic data, such as the estimated values of the radii of gyration of the unit, the dynamic stiffnesses of the mountings, and the influence of the unknown characteristics of the seating.

Vibration troubles in a ship structure are usually due to resonance of the engine unit on its seating, possibly coupled with resonance of the structure at the place where the vibrations appear.

By suitable design, resonance for major forces and couples can usually be avoided, and any resonance points can be so located and selected as to ensure that the damping properties of the rubber units can keep the amplitude of movements and forces within reasonable limits.

DIESEL-GENERATOR MOUNTINGS

Smaller types of Diesel generators, as shown in Fig. 6, are often located on an upper deck or on a bracket in the engine casing, in close proximity to the accommodation. The seatings for such units will by the nature of their location be fairly flexible. Fortunately they usually operate at fairly high speed, say 1,000 r.p.m., and this permits the use of mountings which are flexible compared with the seating. It is thus possible to ensure that all natural frequencies of the units on the mountings are well below the frequencies of the exciting couples and forces in the cases of three-, four-, five- and six-cylinder four-stroke engines with even firing.

One- and two-cylinder four-stroke engines and four-cylinder engines with uneven firing have a large half-order torque harmonic, and practical considerations may not permit the highest of the rolling natural frequencies of the unit to be reduced below the half order. In such cases it is, therefore, usual to select the mountings so as to locate the upper rolling natural frequency between, but well clear of, the half- and first-order frequencies. The major difficulty in applying this solution is the requirement that the value of the rolling radius of gyration be known reasonably accurately. It may therefore be, in some cases, practical to make provision to facilitate a modification of the mountings if this should be required.

All pipe and cable connections to units

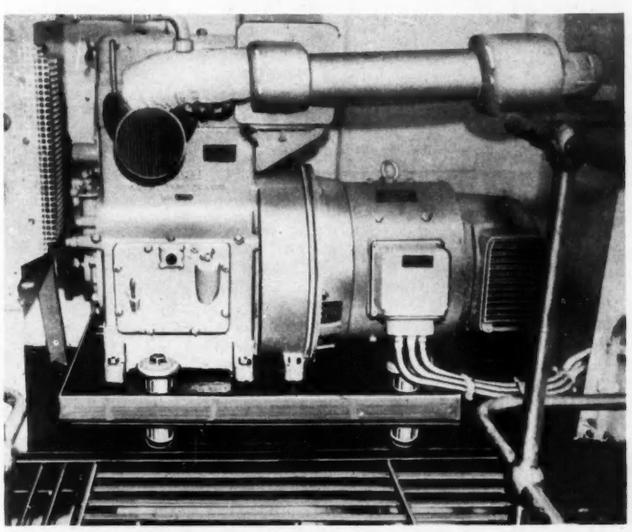


Fig. 6 Four-point mounting system for a small Diesel generator set using two Silentbloc mountings at each point.

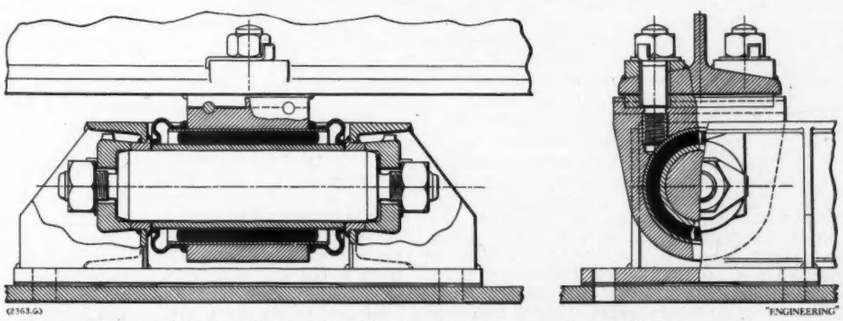


Fig. 7 Method of fitting Silentbloc bearings in a five-cylinder Diesel generator.

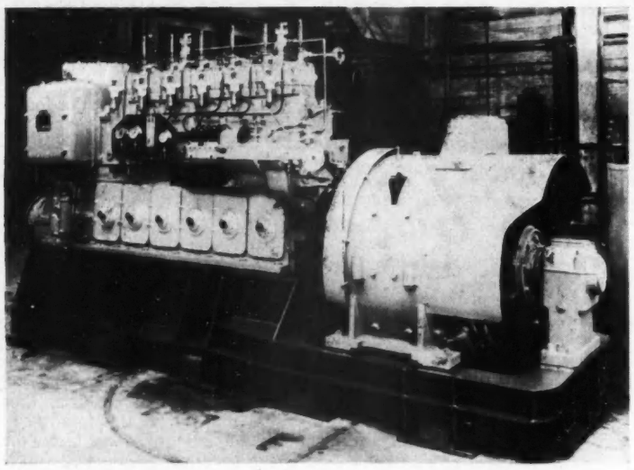


Fig. 8 A Diesel generator set mounted on flexible bearings as indicated in Fig. 7. In this way much of the vibration associated with shipboard plant can be eliminated.

mounted on flexible mountings should be made flexible, so as to permit movements of the units. The flexible pipe connections will reduce the amount of vibration and noise transmitted along the piping to some extent, and a further improvement can be gained by supporting the piping by flexible rubber units and by selecting rigid attachment points on the structure.

The Diesel generating sets located on the tank top in the engine room usually operate at speeds in the range of 300-750 r.p.m. and the number of cylinders per unit is determined according to the power requirements. Due to torsional vibration problems, the degree to which the engines are balanced is limited.

In a typical case of a five-cylinder 375-r.p.m. four-stroke Diesel generator mounted on flexible mountings, the forcing frequencies involved are the first-order pitching and yawing couples, 375 c.p.m., the second-order pitching couple, 750 c.p.m., and the torque harmonics of 2½-5-7½ orders, or 938, 1,875 . . . . c.p.m.

It would be impractical to apply mountings which would make all the natural frequencies of the unit less than 375 c.p.m. The solution is to employ mountings with a vertical static deflection of the order of 0·03 in. with $S/s=1$ for rolling and $S/s = 16$ for pitching, giving estimated natural frequencies of 1,450 c.p.m. vertically, 500 and 3,700 c.p.m. rolling, 325 and 1,700 c.p.m. pitching, and 1,600 c.p.m. yawing. Fig. 7 shows the arrangement adopted using "Silentbloc" bearings; a similar method is employed in the Diesel generator illustrated in Fig. 8.

The yawing and the higher pitching frequencies are well clear. The lower pitching frequency is close to the first-order pitching couple. However, with the mounting characteristics and locations selected the movements will be an almost pure translation, and since the pitching excitation is in the form of a couple, the energy input will be small and, even at resonance, the expected amplitude and the corresponding reactions on the seating will be small.

The higher rolling natural frequency could, with bad luck, coincide with the 10th order torque harmonic, but the amplitudes would be small and would represent comparatively small forces. The exact location of this upper rolling resonance frequency is, however, doubtful, owing to the flexibility of the sub-frame unit.

ROLLING FREQUENCIES CLEAR OF ROTATIONAL SPEED

It is the usual practice, even though a unit is nominally completely balanced and no first order rolling forces or couples are present, to locate the rolling natural frequencies clear of the rotational speed. If a first order yawing couple is present this is essential, because the approximations made in the preliminary design assume that the longitudinal principal inertia and elastic axes are parallel. This is, however, seldom the case. Usually the principal axis of inertia will slope from the engine down to the generator at an angle of about 12 to 15 deg. A correction can be made to allow for this by proceeding as before, with the exception that the yawing couple is resolved into two components with respect to the correct principal yawing and rolling axes, and these components are employed for calculating the rolling and yawing movements. It will be found that the rolling first-order couple derived in this way may be of the order of 20 per cent. of the yawing couple. As a further refinement, H, the height of the centre of gravity over the centre of reaction can be replaced by root-mean-square value of the height of the principal axis over each separate mounting.

Similarly it may be important in some instances to calculate the yawing effect due to the rolling couples.

In the case of variable-speed units, it is usual to try to locate all the natural frequencies of the unit on the mountings low compared to the frequencies of the exciting forces and couples at the lowest speed, and if this is possible, no difficulties should be experienced.

ADVANTAGES OF NATURAL RUBBER

The preferred material for the flexible units is natural rubber in the form of a suitable compound. Natural rubber is not oil-resisting, but this can be counteracted (1) by designing the mountings so as to expose a small surface only to oil, (2) by treating the exposed surface with an oil-resisting coating, (3) by protecting the rubber with metal oil shields; and (4) by shrouding the mountings with flexible shields of an oil-resisting synthetic.

In some applications where no oil protection can be applied it may be necessary to employ a compound of rubber with a synthetic material, or a pure synthetic, but no synthetic compound is as yet available with mechanical characteristics as satisfactory as those of natural rubber.

Thus, natural rubber has less permanent set or creep, and the ratio of dynamic stiffness to static stiffness is less for natural than for synthetic rubber. The greater this ratio, the greater the deflection required to obtain a specific result, the larger the unit will be for the duty, and the greater will be the movements of the mounted engine in heavy sea.

Bonding the rubber directly to metal parts permits a great latitude in design and allows mountings to be produced to carry almost any load. It is difficult to detect bond flaws non-destructively, but by keeping the bond stress low the possibility of flaws developing into a failure may be reduced. Usually such mountings are supplemented by some safety arrangements.

TUBULAR GROWTHS ON THE SURFACE OF CONCRETE

A STUDY OF POROSITY IN DEPOSITED GRANULAR BEDS

By J. Kolbuszewski, PH.D., D.I.C., F.G.S.*

When studying the influence of the size of the container on the resultant porosity of sands deposited by one of the possible methods of deposition in water, the author found† that the porosity decreased when the diameter of the container increased and that changes were bigger in the case of containers having a diameter smaller than 3 in. The influence of the container is usually attributed by some investigators to the "wall friction." Observing the sand grains falling through water in vessels of 1 in., 2 in. and 3 in. in diameter, however, the author was not convinced that the comparatively big changes in porosity could be caused entirely by wall friction in its physical meaning, or by the wall supporting an action leading to arching. The objections were twofold: firstly, because the experiment could be carried out in such a way that practically no grains would touch the wall of the container during the process of deposition; secondly, that the diameter of the grains could be adjusted in such a way that the action of arching would be practically impossible for the grain diameter and the available cross-sectional area of the container.

Finally, when some sort of explanation had to be determined, an experiment was made using powdered mica, and it was noted that during the settlement of the particles in the water some very characteristic vertical channels were formed through which water from the bottom of the container moved upwards, it being simultaneously replaced by the settling material. It was found that the number of channels per unit volume

* Lecturer in Civil Engineering, University of Birmingham.

† J. Kolbuszewski, "An Experimental Study of the Maximum and Minimum Porosities of Sands." *Proc. Int. Conference on Soil Mechanics and Foundation Engineering*, vol. 1, Rotterdam, 1948.

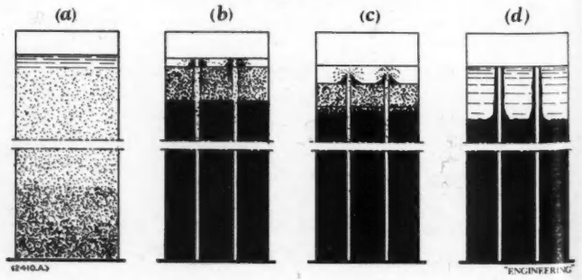


Fig. 1 Diagrammatic representation of the four main stages in the formation of tubular growths on the surface of settling concrete: (*a*) In suspension, (*b*) "volcanoes" begin to form, (*c*) settlement ends and chemical reactions occur, and (*d*) the tubes form at the end of the process.

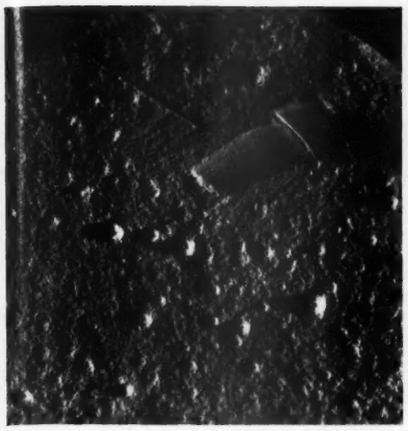


Fig. 2 Cement surface.

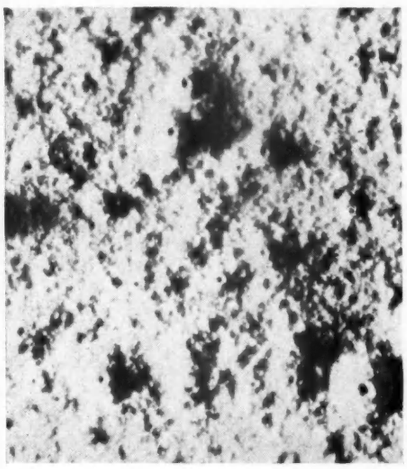


Fig. 3 Detail of Fig. 2.

Figs. 2 and 3 The surface of the deposited cement in the test devised to reproduce the concrete growths.

was always larger in the case of a smaller-diameter container when the same quantity of material was settling than was the case for a large container, when only a few of these channels occurred. It was also established that these channels remained in the settled material after the end of the settling process and that, even in the case of very fine sands such as those passing 100 to 150 B.S. sieves, the same sort of channels were in operation though they could not be clearly seen at the end of the settling process. The author reached the conclusion that it was the different numbers of these vertical channels that affected the porosities in the different containers. The explanation was concerned mainly with the laboratory techniques of deposition of sand materials in various containers which form parts of testing machines where porosity of the sample had to be controlled, though it was realised at that stage of research that the explanation of these channels might be of some significance in the general process of deposition of granular materials in water and the consolidation of the deposited strata under their own overburden.

SITE OCCURRENCE

In May, 1953, a phenomenon occurred during the construction of the pile-cap foundation at the Marchwood power station when, after the placing of a large quantity of fresh concrete, a tubular growth was found on the surface of the deposited concrete, covering it with a formation similar in appearance to a field of grass. The contractors, Sir Robert McAlpine and Sons, Limited, Park-lane, London, sought an explanation of the phenomenon, and an investigation was carried out to explain the reasons for the formation of these tubular elements.

Samples of these tubular growths were sent to the author's laboratory; each was about 3 in. long and had a diameter of about $\frac{1}{16}$ in. at one end and between $\frac{1}{8}$ in. and $\frac{1}{4}$ in. at the other. The first examination suggested that they were made of a material of a calcium character. It was known that the growth was first noticed on the surface of the pile-cap foundation about 24 to 30 hours after the placing of the concrete, but no other observations were available. It was difficult at first to arrive at any explanation of their occurrence, and no description of similar phenomena could be found in any literature on concrete, but when the problem was connected with the experiments in soil mechanics mentioned above, it became clear that the reason for the formation could be easily explained as follows.

The assumption was made that the behaviour of the particles of the concrete (cement, sand and gravel) after being mixed with water and during the initial period after placing and while curing was similar to that of other solid particles in suspension, for example, very fine sands. That implied that the problem of the "vertical channels" was an analogous phenomenon.

EXPERIMENTAL INVESTIGATION

The experiments were carried out using 2,000-c.c. glass cylinders, ordinary Portland cement being mixed with tap water into a thick suspension before being placed.

It was noted that during the settlement of the cement in the water, the same characteristic vertical channels were formed inside the sample through which water from the bottom part of the container moved upwards towards the free surface of water standing on the top of the sample, the rising water being replaced by the settling material. The four main stages of the phenomenon are shown diagrammatically in Fig. 1, opposite. The water, moving upwards, was taking particles of the settling portion of the suspension through the vertical channels, and these particles were deposited on the extreme top layer of the deposit in the form of craters which are shown in Fig. 2; a detail of the surface is shown in the adjacent Fig. 3.

The craters were moving downwards with the sinking top layer of the deposit and particles coming up with water could be noticed erupting from the surface, forming a kind of miniature volcano. The descending particles from the thin suspension, still existing above the extreme top layer, together with the particles coming from inside the deposit, were not, however, sufficient to cover the craters completely as the latter were being simultaneously built up by the newly-arriving particles from inside the settling layer. One of the experiments was stopped at this stage and Figs. 2 and 3 show the surface of the sample with the craters as they appeared after about two hours from the beginning of the settlement. The second experiment was continued and when the visual settlement stopped, and the craters had appeared, it was left and the cylinder and its contents allowed to stand for 72 hours. It was realised that the settlement was not completed and that chemical reactions were taking place at the same time.

It was expected that further settlement would cause further movement of the water and that this movement of water, together with possible discharge of gaseous materials through the vertical channels and the craters, should bring the products of the chemical reactions to the surface and build up the craters to the surface of the free standing water on the top of the deposit, thus forming tubular elements similar to those that appeared at the Marchwood power-station site. An examination of the sample after 72 hours showed that the tubes had formed as had been expected. Fig. 4 reproduces the magnified (about 10 times) picture of a group of specimen tubes. The sample used was $1\frac{1}{2}$ in. in diameter and 6 in. long. The tubes formed were about 0·02 in. in diameter and had a maximum length of $\frac{1}{4}$ in. (equal to the depth of standing water).

Fig. 4 Two of the cement growths (× 10) produced on the surface of the deposited slurry.

The photograph of the tubes, taken by means of a special magnifying objective, revealed the shape of the formed tubes to be very much the same in character as that of the samples taken from Marchwood. Examination of the sections of the samples showed that the vertical channels formed in the concrete remained in it after setting, and they could be seen to have a diameter approximately equal to the internal diameter of the bottom part of the tube. The number of these vertical channels appeared to be larger than the number of the tubes and craters formed on the surface, as they were in some cases connected together and had a common exit on the surface through one crater.

CONCLUSIONS

In conclusion, it can be said that the phenomenon of the growth of tubular elements on the surface of the concrete will be experienced when loose wet material undergoes settlement to such an extent that a few inches of water are found standing on the surface after the placing of the concrete. The set concrete will then have numbers of vertically inter-connected channels of variable diameter (mostly capillary in size) remaining in it after settling. It seems possible that movements of water in the concrete through these capillary conduits is to be expected if no preventive measures are taken.

Acknowledgments.—The author is indebted to his colleagues for their interest in the problem, particularly Mr. F. W. Pinkard, of the Department of Chemistry, Mr. K. A. Macfadyen, of the Department of Physics, and Mr. H. V. Hill, of the Department of Civil Engineering.

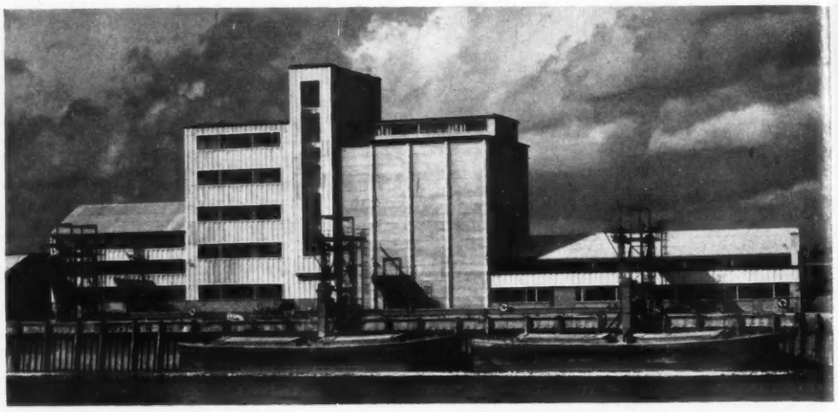
RESEARCH ON COAL UTILISATION

In the course of his speech when proposing the toast of "The B.C.U.R.A." at the annual luncheon of the British Coal Utilisation Research Association, held in London on October 13, the Hon. Lancelot Joynson-Hicks, M.P., Parliamentary Secretary to the Ministry of Fuel and Power, referred to the fact that the Association had only been in existence for a relatively short time. He said that it was not until 1938, when the need for the conservation and efficient use of coal had become apparent, that the Association had been formed. The National Fuel Efficiency Service had now been set up to take over on a wide scale the Ministry's activities in the field of efficient fuel consumption in industry, and there was no doubt whatever that the greater the efficiency in fuel usage, the greater the efficiency of industry itself. Although smoke was evidence of the inefficient burning of coal, the absence of smoke was not necessarily evidence of the efficient consumption of coal. Dust, grit and sulphur might still be going up the chimney. Thus, last year, 2½ million tons of sulphur had been wasted by release into the air of this country, with all the damage, cost and possible danger to human welfare which that involved, and at the same time four million dols. had been expended in importing sulphur from America.

Sir Charles Ellis, F.R.S., President of the Association, who replied to the toast, drew attention to the healthy and vigorous attitude shown towards research problems by scientists in the coal industry. In his response to the toast of "The Guests," proposed by Mr. H. Christopher, J.P., a vice-president of the Association, Dr. Alexander Fleck, chairman of Imperial Chemical Industries, Limited, said that research embraced three distinct activities. The first involved fundamental and general exploratory research; the second, research necessary to maintain and improve the production of existing products; and the third, research on new products up to the stage at which sufficient information was available to enable a full-scale plant to be designed. Development work took up matters where research had left off and it, too, had three distinct aspects. The first comprised the experimental and investigational work required to maintain and expand the sales of existing products. The second involved facilitating the introduction, as commodities, of new products, including the construction and operation of pioneer plants, and the third consisted of market research. Development called for even greater collaboration between members of the Association and the research teams at Leatherhead, than did research, if industry were to receive the full benefit of the Association's work.

During the luncheon, Sir Charles Ellis presented the third Coal Science Medal to Professor D. W. van Krevelen, part-time professor at the Delft Institute of Technology and director of research of the central laboratory of the Dutch State Mines, Maastricht. These laboratories, said Sir Charles, were unique in that they served an integrated coal and chemical industry, an industry which produced not only coal but also fertilisers, sulphuric acid, organic solvents and basic chemicals for synthetic-fibre manufacture. The laboratories included pilot plant for high-pressure reactions and studies in heterogeneous catalysis. Dr. van Krevelen had done important work on heat transfer in fluidised beds, the drying of granulated materials, and the structure of coal and its behaviour on heating.

After the luncheon. Professor van Krevelen delivered the third Coal Science Lecture on "The Problem of Coal Constitution." In this he described researches which had as their object the determination of the chemical structure of coal. He then outlined his prospective investigations into organic group analyses, the structural changes caused by chemical processes such as oxidation, the elucidation of the physical and chemical mechanisms of carbonisation, and the relationship between methane release from a coal seam and the structure of the coal.



Cement is brought to the new London depot of the Blue Circle Group by lighters from works further down the river. The lighters are shown here being discharged through the three wharf-side unloaders which each have a capacity of 150 tons per hour.

RIVERSIDE CEMENT DEPOT FOR LONDON

HANDLING AND DISPATCHING IN BULK

A cement depot—unique in that the cement is delivered from the works in bulk by river barges which are mechanically discharged, in all weathers, into silos; from the silos, the cement can be packed in bags or it is discharged directly in lorries for bulk transport to the contractor's site—has recently been brought into operation by the Cement Marketing Company, Limited, at Carnworth-road, Fulham, London, S.W.6. The depot has been designed for storing and handling up to 6,000 tons of cement a week and for distributing the cement by road to the Greater London area.

The cement is delivered to the depot from three Thames-side works in 330-ton self-unloading lighters which can be handled three at a time; each lighter is unloaded at the rate of 50 tons per hour and the cement conveyed to the top of the storage silos by a system of screw conveyors, elevators and air slides. A second system of air slides is used to extract cement from the silo and to deliver it to the packing machines or lorry-loading points. Where cement still has to be despatched packed, the filled bags are carried on to the lorries by retractable conveyors. Throughout the depot the actual man-handling of the cement has been virtually eliminated and, as may be judged from the accompanying illustrations, the internal appearance of the main building is one of spacious cleanliness—a cleanliness which is to be scrupulously maintained by the constant use of vacuum cleaners.

An office block, sundries store, workshops, repair garage and covered standing space for 30 lorries have also been provided. The packing and loading buildings have a reinforced-concrete frame clad with asbestos-cement sheets, except at lower levels where concrete blocks have been used. The office and canteen block is a reinforced-concrete frame with an infilling of lightweight-concrete blocks which have been rendered with Cullamix. The civil-engineering consultants for the depot were Oscar Faber and Partners, London-road, St. Albans, Herts., and the general building contractor, John Mowlem and Company, Limited, Ebury Bridge-road, London, S.W.1.

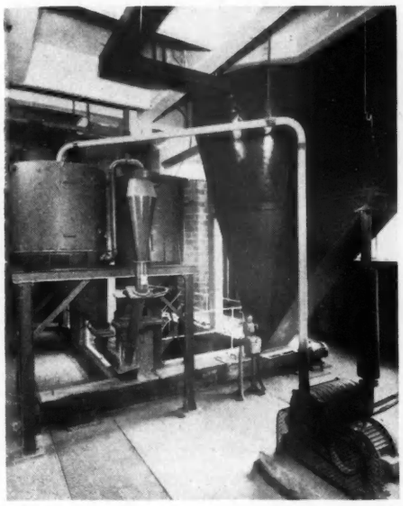
LIGHTERS

Nine lighters, to be worked normally in groups of three, have been provided. Each has a nominal capacity of 330 tons and is of the self-unloading type, the discharge rate being about 50 tons per hour. The discharging system comprises a cross-scraper conveyor located amidships which collects the air-fluidised cement and delivers it to a small hopper on the deck. This hopper forms the boot of the unloading bucket elevator which is on the wharfside and delivers the cement to the conveying system leading to the silos.

The holds of the lighters have false floors forming air-fluidising conveyors sloping at 8 deg. from the fore end aft bulkheads towards the midships of the lighters, finishing flush with the trough of the scraper elevator.

Each floor is divided into eight sections, each forming a longitudinal conveyor running from one end of the lighter down to the amidships section. A separate air feed is taken to each conveyor at its lowest point, these 16 air pipes being brought through the deck across the centre of the lighter and joined to an air manifold; a cock on each pipe controls the air to whichever conveyor is required. A flexible pipe connects the manifold to a blower adjacent to each unloading station.

Throughout the depot the cement is handled by screw conveyors or by air-slides such as these which are used for filling the silos. The air intake for the slides and into the silos is through the canvas filters shown here.



Turbo-exhauster of the cleaning plant installed for bulk collection and general vacuum cleaning.

The centre of the lighter, where the scraper elevator is located, is partitioned off by two transverse bulkheads running from deck level to 1 ft. above the air conveyors. These enable the machinery to be isolated from the bulk of cement in the holds should any maintenance work be required on a loaded lighter. Longitudinal wash plates run from these bulkheads to half way along each hold from deck level to the air conveyor surface. These stabilise the lighters while being loaded with fluidised cement.

The drive for the transverse scraper elevator is by a 7½-h.p. motor on the deck of the lighter, the 415-volt supply being obtained from a power point on the wharf. An emergency stop button is fitted on the lighter itself but otherwise there is no electrical control gear on board. The drive is interlocked with conveying equipment to the silos so that if any hold-up occurs in this part of the plant the lighter discharge automatically cuts out.

To date, the lighter holds have been covered with the normal timber and tarpaulin hatch covers to facilitate observation of the cement. These will be replaced subsequently by steel tank tops with inlet ports for loading the cement as well as for observation and access doors.

CEMENT TRANSPORT TO SILOS

Three fixed unloaders are provided on the wharfside, each comprising a bucket elevator having a capacity of 50 tons per hour, mounted on a pivoted system which enables the elevator to move with the lighter as the tide varies. When the lighter is in position, the elevator is lowered down into the deck hopper by means of a hand winch, and an apron is provided on the elevator case to connect to the flange of the hopper so that a dust-tight connection is formed.

Forming part of each unloader is a screw conveyor flexibly connected to the bucket elevator; it discharges into a system of 20-in. and 24-in. dia. screw conveyors which run along the front of the wharf to a mid-position, where they discharge into a 24-in. dia. screw which transports the cement to the silo conveying system. (If a second packer has to be installed a further transverse screw conveyor will be added.) The electrical equipment for each unloader, together with that for the supply to the lighter, is mounted on the side of each steel structure.

In the conveyor system for the silos, the cross screw which brings the cement from the wharfside conveyors discharges it into an 86-ft. high discharge elevator, which takes it to the top of the silos and discharges it either directly or by means of a cross air slide into one of two air slides which run the length of the silo block. The elevator and each air slide have a capacity of 150 tons per hour, and by means of swivel ploughs the cement can be directed into the silo required. Two Alldays & Onions high speed fans, each having a capacity of 475 cub. ft. per minute at 30 in. water gauge provide the air for the slides; only one fan is normally required.

The main screw conveyors along the wharfside are at ground level and special precautions have been taken to render them waterproof. Covers are of the self-sealing type and provision is made for draining away any water that might get into the seal.

STORAGE AND EXTRACTION

The silos are of reinforced-concrete construction, forming a compact rectangular block divided into twelve compartments arranged in three rows of four. The total capacity is 6,000 tons.

Each silo is provided with three internal air slides arranged in arrow formation to fluidise the lower layers of cement. The cement is conveyed to the packing plant elevators by means of two 12-in. air slides, the rate of discharge from the silo being controlled by an air feeder. One feeder is provided for each of the two outer rows of silos, but for the centre silos two feeders are provided, so that the cement in this row may be delivered to either of the main extraction air slides. Cross-over air slides are provided so that either extraction air slide may discharge into either packing plant elevator.

Two Alldays & Onions' blowers, each having a capacity of 520 cub. ft. of air per minute at a pressure of 3 lb. per square inch, are provided for the air slides inside the silos and two of the same company's high-speed fans, having a capacity of 450 cub. ft. of air per minute at 30 in. w.g., are provided for the air feeders and the two main extraction air slides, but only one blower and one fan are required at any one time.

The supply of air from the blowers is controlled automatically by means of electrically-operated Tate unloading valves, which are operated by the high- and low-level device in the packer hopper. The whole of the conveyor system is interlocked to ensure correct operation.

PACKING

The packing machine is a 12-spout Fluxo plant, made by F. L. Smidth and Company, Limited, London, and comprises a 24-in. slow-speed central-discharge elevator, a rotary screen, hopper, pneumatic feeder and packer, and a dust filter. High- and low-level devices of the Tektor type are provided in the packer feed hopper to ensure that the head of cement on the machine is kept within the prescribed limits.

A Broom & Wade air compressor, having a capacity of 100 cub. ft. of air per minute at a pressure of 30 lb. per square inch, is provided to operate the pneumatic equipment. Provision has been made for the installation of a second one. This compressor is driven through a hydraulic coupling so arranged that when full pressure has been reached in the air receiver, the compressor automatically stops running, the motor continuing to run normally. With this arrangement it is hoped to reduce the maintenance on the compressor.

DISPATCH

The bag store is arranged over the loading bay and when stacked to a height of 9 ft. (the maximum permissible) it has a useful capacity of about 750,000 bags. The loading arrangements comprise a 24-in. flat belt conveyor of sufficient length to allow for the addition of a future loading point to make a total of four. A burst-bag hopper is provided at the end of the belt. Three 24-in. flat belt retractable conveyors are provided, suitable for loading the longest lorries now in use.

The elevator screen and hopper for the second packer forms an easy method of obtaining screened cement for bulk loading. The cement is taken from this hopper through a pipe and a flexible hose to the waiting vehicle, and provision is made to ensure, as far as possible, that the operation of filling the lorry shall be dust-free.

POWER SUPPLY

Two alternative supplies are provided by the London Electricity Board whose substation is located at the north-west corner of the site.

A 500-kVA transformer provided by the Board reduces the incoming supply from 11,000-volts, 3-phase, 50-cycles to 415-volts, 3-phase, 50-cycles, which is the voltage of the supplies throughout the depot. Two feeders connect the Board's substation with the depot substation in the basement of the packer building. The main switchboard in this substation has been made by the English Electric Company, Limited, and is divided into two by means of a section switch, and the Board's two feeders are connected one to each half; this should ensure that at no time is the whole of the plant shut down as the result of a fault, and it also permits maintenance being carried out on half the board while the other half remains in service.

There are a number of distribution boards throughout the plant which are supplied from the main switchboard in the depot substation and these supply the adjacent machinery; starters are in some cases of the hand-operated Ellison type and in others of the contactor type. All starters are fitted with isolating switches and, where necessary, emergency-stop push buttons have been provided.

EXTENSIONS TO WORKS

To provide the necessary facilities for bulk loading the lighters at the Kent Works, Stone, near Greenhithe, two new reinforced-concrete silos have been built and a system of air slides installed to serve both the new and existing silos. A new jetty accommodating three lighters simultaneously has also been constructed and the capacity of the conveying system is sufficient to load one lighter in approximately one hour whatever the state of the tide.

The depot is equipped for dispatching the cement in bulk, but these retractable conveyors are also available for loading bagged cement on to lorries.

SILICONE PRODUCTION

PLANT AT BARRY NOW IN OPERATION

A plant for the manufacture of the materials known as silicones has been erected at Barry, Glamorganshire, by Albright and Wilson, Limited, 49 Park-lane, London, W.1, and is now in production. Marketing is being undertaken by Midland Silicones, Limited, 19 Upper Brook-street, London, W.1.

Silicones are organic compounds of silicon having a basic structure of alternate atoms of silicon and oxygen with organic groups attached to the silicon atoms. A typical composition is $(CH_3)_3$ $SiO[(CH_3)_2$ $SiO]_n$ $Si(CH_3)_3$ where n may vary between zero and several thousand. This particular series of polydimethylsiloxanes ranges in viscosity from 0·65 to 1,000,000 centistokes.

PROCESSES USED

Two processes are used in the manufacture and both are in operation at Barry. One, the "direct," consists of passing the vapours of organic chlorides over silicon metal at about 300 deg. C. with small amounts of copper or silicon to act as catalyst. The reaction produces a mixture of chlorosilanes with one, two or three, organic radicals.

The second method employs the Grignard process in which silicon tetrachloride, prepared by the reaction of silicon and chlorine gas at about 1,000 deg. C., undergoes a series of reactions with organic chlorides in the presence of magnesium metal in an atmosphere of ether. Again a mixture of chlorosilanes is produced together with magnesium chloride.

By whichever process they are made, the chlorosilanes are separated by fractional distillation. The process is a sensitive one as the boiling points are very close together. Moreover, chlorosilanes are highly inflammable, toxic and corrosive. After separation, the fractions are hydrolysed and condensed and by blending the different chlorosilanes a great variety of products can be made. These products are the silicones.

LAYOUT FOR SAFETY

The plant at Barry was designed and built (apart from some special items) by Albright and Wilson, Limited, with full assistance from the Dow Corning Corporation. A large tank farm was built, as may be seen in Fig. 1, to store both raw materials and intermediate products. In the construction, use was made of some concrete settling tanks which had been built on the site during the war. Incoming solvents, which include toluene, are transferred to the storage tanks by pumps, but methyl chloride, which is delivered by road, is unloaded by using its own vapour pressure. The tanks, and all other parts of the system, are purged with inert gas to prevent the ingress of air or moisture and to reduce the risk of fire. The personnel wear protective clothing as may be seen in the illustration.

The chlorosilanes from both processes are fed to the distillation plant which is illustrated in Fig. 2. This is constructed in another of the old settling tanks and the view of the tank farms (Fig. 1) was taken from it. Owing to the closeness of the boiling points, the distillation columns must be highly efficient as it is important that the fractions obtained should be very pure. Here again, the operation must take place under entirely anhydrous conditions. In the illustration (Fig. 2) the left-hand column is for recovering ether and the remaining six for chlorosilane separation.

ACCURATE DISTILLATION CONTROL

Control of the distillation plant is carried out by automatic instruments arranged on a graphic panel. Part of this is shown in Fig. 3. It extends nearly right round the control room and is believed to be one of the largest of its kind in Europe. Signals are given simultaneously on the plant and on the panel, the control room being at some distance from the columns. Emergency systems are available to operate the plant for a time in the event of an outside power failure.

From the columns, the fractions are pumped to tanks on the roof of the building housing the hydrolysis plant, whence they are fed by gravity to the different units. Cocks are fitted to these tanks so that, in case of emergency, the contents can be drained back to the tank farm. Throughout the hydrolysis plant, a small section of which is shown in Fig. 4, every precaution has been taken to reduce the fire risk. Flameproof equipment has been used, and all switchgear for controlling the pump motors is located in an adjoining room. After condensation, which is effected under vacuum, the silicone fluids are filtered in filter-presses and stored in drums according to their grades.

From the store, the fluids are sold for various purposes, or are sent to other departments to be converted into elastomers, compounds and greases. Elastomers are formed by thickening the fluid and adding a pigmented filler in a roller-mill. It is extremely important that there should be no contamination by organic material at this stage or a faulty product will result. The putty-like sheets formed are then dispatched, carefully wrapped in a transparent film, for moulding or extrusion, followed by curing to form silicone elastomers. Silicone elastomers were the first synthetic rubbers to be made in this country and probably form the largest single outlet for the products of the Barry plant. When the plant is working fully an output of about 600 tons of chlorosilanes per annum is expected.

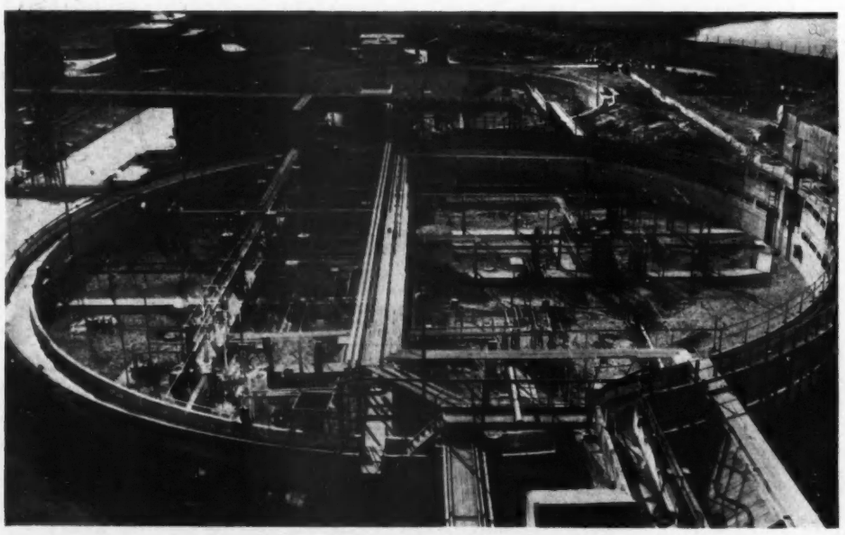


Fig. 1 Raw materials and intermediate products are stored in buried tanks to reduce fire risks.

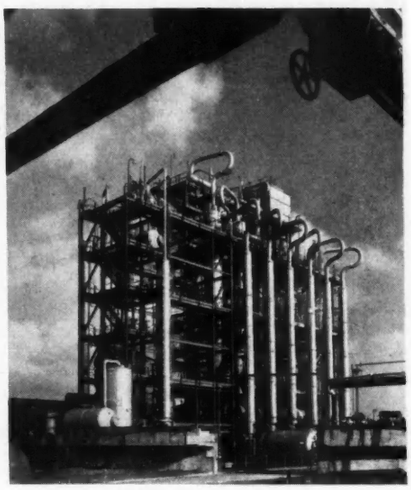


Fig. 2 Very accurate distillation is required necessitating long columns and several stages.

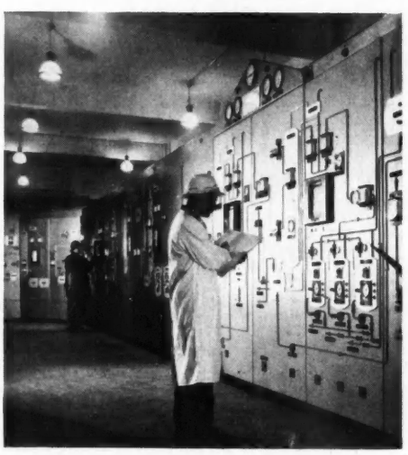


Fig. 3 The control panels for the distillation plant extend almost completely round the control room. About one-third is shown here.

FIELD OF APPLICATIONS

Although known for many years, it was not until just before the war that commercial production was considered. During the war, production began in America of silicone resins which would give heat-stable electrical insulation. Since the war, the range of types available has increased and with it the field of application. The heat-stability of silicones is still one of their chief advantages but their property of repelling water is becoming of increasing importance. Thirdly, their "non-stick" properties are now being exploited.

It is only possible here to indicate briefly some of the uses to which silicones are now being put. The fluid forms are used in diffusion pumps for high vacua, high-temperature oil baths (they are stable at 250 deg. C.) and those in the higher viscosity range (1,000,000 centistokes) in viscous dampers. Another range is used as release agents in the moulding of rubber or shell-

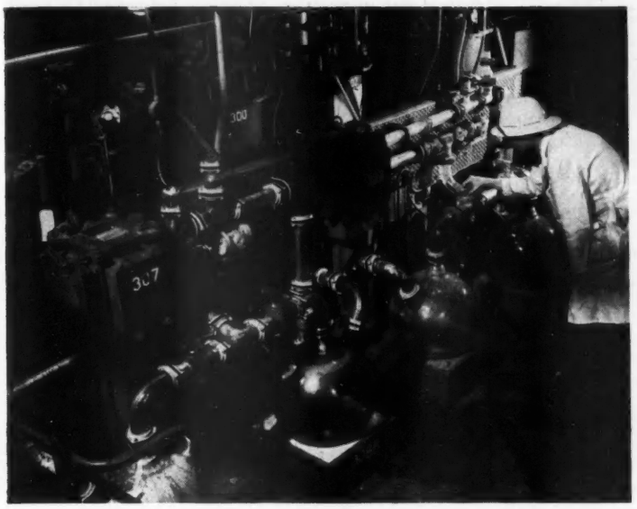


Fig. 4 Part of plant for hydrolysis of chlorosilanes to form silicones. The process is carried out in an inert anhydrous atmosphere using flameproof equipment.

moulds and in baking, for food products do not adhere to a treated surface. Part of the fluid range is used to form water repellents for glass, ceramics, paper, textiles, leather and masonry. Silicone resins and varnishes are used as electrical insulators for high-temperature work giving class H insulation which has proved effective for intermittent exposure to temperatures up to 300 deg. C. Laminating, bonding, and moulding resins are also being produced.

But it is probably as synthetic rubbers that the field is widest. Silicone elastomers remain usable between − 90 deg. C. and + 250 deg. C. They can be moulded or extruded in very intricate forms and can be reinforced with glass or asbestos fabric to make tear-resistant diaphragms. Silicone compounds are used as antifoaming agents and waterproof seals, while silicone greases have heat-stable characteristics and so can be used for many arduous duties including high-temperature high-vacuum work.

* * *

RESEARCH ON PACKING FOR TRANSIT AND STORAGE

New Facilities for Export Packing Services, Limited

On Thursday, October 14, the Parliamentary Secretary to the Ministry of Supply, Sir Edward Boyle, Bt., M.P., opened a new research and development centre for Export Packing Services, Limited, Sittingbourne, Kent. The new establishment, believed to be the first of its kind to be launched by private enterprise, is regarded by the company as "a step towards . . . the elevation of packing from the state of a rough-and-ready end process to that of an engineering science that can be regarded as an integral part of production."

The new centre comprises a two-storey building housing chemical and physical laboratories, test houses, workshops and drawing offices on the ground floor, and on the first floor additional laboratories, administration offices, a conference room, and a projection room for cinematography. The whole building has been completed within the last five months.

Most of the work of Export Packing Services, Limited, is concentrated on packing equipment supplied to Government contracts—aircraft, motor vehicles, electrical and electronic equipment, etc.—and it is necessary not only that such stores shall adequately withstand shock loads and vibration during transit but also that they shall survive storage in depots for many years, in extremes of temperature and humidity, without deterioration.

The research programme, therefore, will include dynamic testing of cushioning and suspension media to build up reliable design data; examining and testing equipment to assess its fragility; recording the effects on test packs of hazards arising from climate, transport, storage, corrosion, vibratory and sudden shocks; designing and developing new instruments for the various researches; and investigating new materials and techniques and their application to packing. Types of materials which will be investigated include rubber cushioning materials, compound materials such as glass fibre and other resin-impregnated fibres, and moisture-vapour barrier materials. The latter will be assessed by methods already developed by the Printing, Packaging and Allied Trades Association.

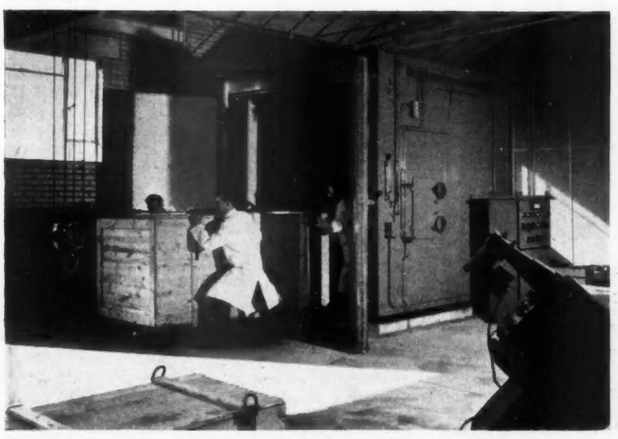
The development of suitable instrumentation is the primary problem, and already an apparatus for determining the properties of cushioning materials, such as rubber or rubberised hair, has been constructed. In this equipment, the test material is sandwiched between metal plates forming an electrical condenser and a mass, guided by three upright members, is allowed to fall on the assembly. The change in electrical capacity provides, on a cathode-ray oscillograph, an indiction of the acceleration, velocity and displacement of the upper plate on impact.

The main test house has a granite-filled concrete floor into which have been let two large concrete blocks, 3 ft. deep, insulated from the main floor by cork. One of these blocks supports vibration bump-test equipment capable of "bumping" a 500-lb. case four times a second with an amplitude of 1 in. The other insulated block, provided with a steel faceplate, is used for free drop tests of packs from a specified height. The loads to which the component, within its packing case, is subjected are determined by an electrical recording accelerometer.

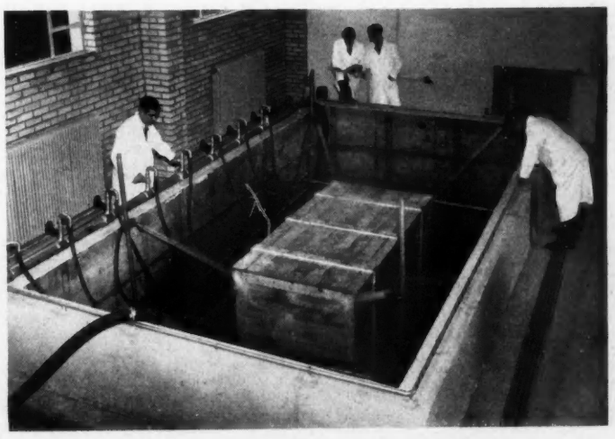
Shown in the left-hand illustration below is a humidity chamber for large packing cases, believed to be one of the largest chambers in the United Kingdom, for simulating tropical temperatures and humidities up to 100 per cent. It is provided with automatic temperature and humidity cycling equipment and recording instruments. In the laboratories, smaller humidity cabinets are used for testing material specimens to determine their permeability to water.

The right-hand illustration shows the rain-making tank in which the weather-proofing of packing cases is tested by high-velocity water sprays which are directed at the four sides and corners of the case. In the near future a low-temperature chamber will be added to the test facilities.

One of the difficulties which sometimes confronts packing specialists is a lack of detailed information on the equipment they are required to pack. For example, it is not easy to design the optimum form of support blocks for a piece of equipment if the packing designer does not know where its structural strong points are located. For such reasons Export Packing Services, Limited, ask equipment manufacturers to co-operate with them from the design stage of the equipment so that the most suitable form of packing can be adequately developed in readiness for the completed component or machine.



Humidity chamber for large packing cases.



Rain-making tank.

3,720-H.P. KOEPE WINDER

ELECTRICALLY-OPERATED EQUIPMENT AT BRADFORD COLLIERY

While the winder at No. 2 shaft Bradford Colliery, Manchester, had to be designed so that ultimately coal could be raised from a depth of 3,822 ft., it had also to be possible for it to be capable of dealing temporarily with seams at depths of 2,802 ft. and 3,312 ft. The National Coal Board therefore decided that these conditions would best be met by the installation of a Koepe winder. Although common in the Ruhr and other European coalfields, this type of equipment is almost unknown in the United Kingdom and the installation at Bradford is said to be the first of a large size to be commissioned in this country. The main contractors were the Metropolitan-Vickers Electrical Company, Limited, Manchester 17, and the Bradford equipment is the first of a number of similar units which the company have in hand for the National Coal Board.

MECHANICAL AND ELECTRICAL DESIGN

The mechanical parts of the Bradford Colliery winder, which is illustrated herewith, were manufactured at the Fraser and Chalmers Engineering Works, Erith. The Koepe wheel, which is 24 ft. in diameter, is of welded construction, there being 14 pairs of channel-section arms. These arms are attached to a cast-steel boss and are fitted to the shaft with tangential keys and shrink rings. The shaft is carried in self-aligning bearings, the bushes of which are lined with white metal. A pump is fitted to each of the main bearings to ensure a supply of oil at low speeds. As it was felt that the best design of lagging could only be determined by experience, it was decided that the initial installation should consist of grooved elm blocks as this timber, in conjunction with locked coil ropes, has shown good resistance to wear under similar conditions at the Emma colliery of the Dutch State Mines.

To begin with, a rust-resisting rope 2¼ in. in diameter, weighing 72 lb. per fathom and having a breaking load of 278 tons, has been installed, but this may be replaced when the 3,822-ft. level is brought into use, the winder having been designed for a 2⅞-in. multi-strand rope weighing 84 lb. per fathom. The ratio of pulley diameter to rope diameter is 100 and the pressure of the rope on the lagging is 236 lb. per square inch. The non-rotating rust-resisting balance rope is of the multi flattened-strand type and is 2·7 in. in diameter, its weight being 72 lb. per fathom.

The winder is driven by two 660-volt direct-current motors of Metropolitan-Vickers manufacture. The root-mean-square rating of these motors is 3,720 h.p., the normal working peak being 6,000 h.p. and the peak torque for rope changing duty 8,000 h.p. They are supplied from a motor-generator set in a separate power house, the set consisting of a 3,070-h.p. 6·6-kV synchronous induction motor running at 750 r.p.m., and directly coupled to the two generators. These generators are electrically interleaved with the winder motors. The induction motor is fitted with power factor control and is excited by a 26·4-kW 43·5-volt overhung generator. The Ward Leonard exciter, which is overhung at the opposite end of the set, has an output of 23·3 kW at 220 volts. The electrical control system is of the standard open-loop type and will provide motor speeds of 260, 308 and 357 r.p.m. in the first, second and third stages, respectively.

Control of the Ward Leonard set is effected from the winding-house floor where a signal relay cabinet and mine-hoist recorder are also mounted; while that of the winder itself is exercised from a cabin on a platform in line with the Koepe wheel.

The winder motors are coupled to the wheel through Bibby flexible couplings and single-reduction gearing with a ratio of 8·68 to 1, manufactured by David Brown and Sons (Huddersfield) Limited, Huddersfield. Both of the pinions are of 0·5 per cent. carbon forged steel, while the gearwheel is of welded construction and has a face width of 28 in. The gears are totally enclosed in a mild-steel casing. This arrangement will give a maximum Koepe wheel speed of 30 r.p.m. during the first stage and of 35·5 r.p.m. and 41 r.p.m. in the second and third stages of operation. The main spur gearwheel is on the same shaft as the Koepe wheel and the whole is mounted on three pedestal bearings.

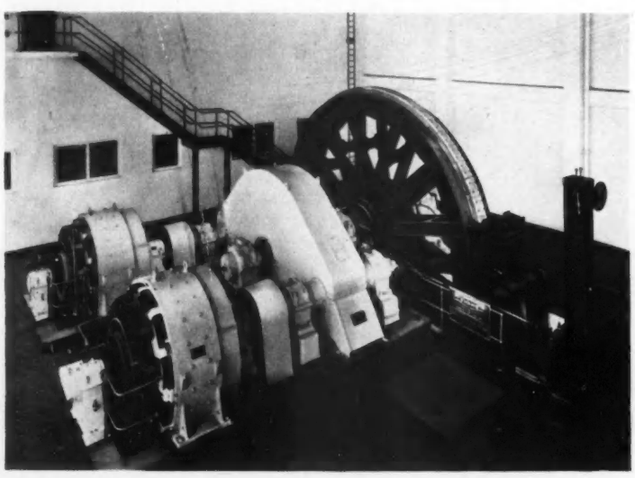
ROPE CHANGING WINCH

As the wheel is of the non-magazine type a separate winch has been installed in the headgear structure for rope installation and changing. This winch comprises a plain cast-steel cylindrical drum 8 ft. in diameter and 8 ft. wide, which was made in halves and is secured to the shaft by tangential keys and shrink rings. It is fitted with a mild-steel shell and is driven through double-reduction gearing by a 300-h.p. slip-ring induction motor which is controlled from the driver's platform. The switchgear and liquid controller for this winch motor are installed outside the air lock in a room adjacent to the winding-engine room.

The depth indicator is of the vertical screw type, the travel of the indicating nuts being 6 ft. It is fitted with two dials which magnify the distance during the last two or three revolutions of the wheel. The indicator is driven from the wheel shaft through gearing and is fitted with a vernier-type coupling so that adjustment for rope creep can be made. This coupling operates a protective switch while adjustment is taking place.

The main brakes are of the straight-post type with Ferodo-lined blocks. They are applied by the Metropolitan-Vickers spring system, the engine being oil-operated and, with its control gear, being installed in the basement beneath the winding engine. The winch brakes are of the calliper type and are applied by a weight-operated engine working under oil pressure. There is also an emergency brake, which operates on a path which is fitted to the motor coupling, the effort being applied by an electro-hydraulic thrust.

The winder operates two skips, each with a capacity of 12 tons, giving an estimated output of 400 tons per hour from each of the three levels.



3,720-h.p. electrically-operated Koepe winder being installed at Bradford Colliery, Manchester. This is the first large winder of this type to be employed in this country.

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NEW TRANSFORMER FACTORY

Modern Production Methods at Walthamstow

As far back as 1950 the Fuller Electrical and Manufacturing Company, Limited, Fulbourne-road, Walthamstow, London, E.17, planned to extend their factory in order to meet present and future demands for larger and higher voltage transformers. It was not until May, 1953, however, that, owing to existing restrictions, the buildings which will shortly be in operation could be begun.

This new shop is a steel-frame structure, which is 75 ft. high and is carried on mass reinforced-concrete foundations. In order to deal with the exceptional weights that will have to be handled particular attention has been paid to the lifting equipment, and crane rails have been laid at two levels. There will be two 100-ton and ten 10-ton cranes at the upper level, while at the lower level a total lifting capacity of 75 tons will be available.

TESTING PLANT

Other equipment will include drying and impregnating plant, the vacuum pot of which is some 20 ft. below floor level; and a 200-ton press which will enable the windings to be pre-shrunk so that they will not subsequently move on the cores. A 30-MVA testing plant is also to be installed which will enable all the necessary power frequency investigations to be simultaneously made on a number of high-voltage transformers. A new 2,000-kV surge generator, which together with its auxiliary transformer, will be mounted on trolleys, is to be provided. When not in use in the test area it will be possible to return this equipment to a recess in the south wall of the building, thus freeing a considerable amount of production floor space. To facilitate the dispatch of the largest units, provision is to be made for the entry into the building of road vehicles capable of carrying over 200 tons, while the gates giving on the main road will be 40 ft. wide.

TRANSPORTABLE WELDING SETS

Road or Site Trailer Units

A new range of welding sets driven by Ford engines has been introduced by the Quasi-Arc Company, Limited, Bilston, Staffordshire. Two sizes are being made having maximum outputs of 300 and 400 amperes. Both models can be fitted with either the Diesel or petrol version of the four-cylinder Fordson Major engine. The sets can be mounted on either a two-wheeled pneumatic-tyred chassis with independent suspension suitable for high-speed road towing or on a four-wheeled unsprung frame having steel wheels or semi-pneumatic tyres. The former is shown in the illustration.

The construction of all four models has been standardised as far as possible. The base-frames, which have the same outside dimensions are of all-welded construction and are manufactured from heavy section rolled-steel channel. All the base-frames are drilled for the attachment of either type of undergear.

The canopy of heavy-gauge sheet steel is standard for all four models. Four louvred sliding doors in the sides of the set give easy access to the engine and generator. The ventilation of the sets has been so arranged that it is possible to run them with all four doors closed. A quickly-detachable panel at the front gives access to the starter battery. The radiator is protected by a stout grille built into the rear of the canopy.

The generator of the 300-ampere set is the firm's type G.300, which incorporates dual control of voltage and welding current. It has a welding current range of 20 to 300 amperes direct-current and an open-circuit voltage of 55 to 70 volts.

The generator of the 400-ampere sets has concentric controls and gives a welding-current range of 60 to 400 amperes direct current, with an open circuit voltage of 50 to 90 volts.

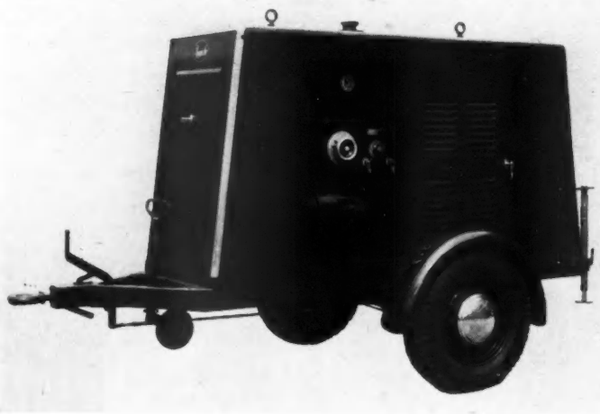
Both these generators are constructed in accordance with B.S. 638.1954. They are fitted with resiliently mounted control boxes which protect the instruments and controls from vibration which might otherwise be transmitted from the engine.

Interchangeable parts are used as far as possible in the Fordson Major Diesel and petrol engines and the mounting hole dimensions and positions are the same for both. Both engines run at 1,500 r.p.m., giving 34 horse-power. An hour counter can be fitted for indicating when an engine is due for oil changes and maintenance.

Another accessory is a semi-automatic idling device operated by a solenoid controlled from a switch attached to the electrode-holder handle. This can give a fuel saving, particularly when the set is being operated at a low duty cycle.

The two-wheeled undergear consists of two units, a tow-bar and a wheel unit which can be bolted to the base-frame of the welding set. The tow-bar is fitted with an overrun braking mechanism and a hand brake lever which operate on Girling-type brakes with 10-in. diameter drums. Two 16-in. diameter pressed-steel wheels complete with 6·50-in. by 16-in. pneumatic truck tyres are fitted to the wheel unit. These wheels are independently suspended by means of Flexitor units which consist of a cylindrical shaft bonded to a rubber block which is also bonded to and contained by a steel housing. Two retractable stands and a front retractable jockey wheel are also provided.

The four steel-wheeled undergear which is unsprung and suitable for moving a welding set around a site consists of a rear axle and two wheels and a front turntable steering unit complete with tow-bar.



Mounted either on two wheels, as shown, or on four, the welding generator can be driven from either a petrol or a Diesel engine.

* * *

DRAG-LINE EXCAVATOR

American Model Made in Britain

Under an agreement negotiated with the Baldwin-Lima-Hamilton Corporation, Lima, Ohio, U.S.A., by Jack Olding and Company, Limited, Hatfield, who are their United Kingdom distributors, 3½-cub. yd. dragline excavators of the type shown in the accompanying illustration are being manufactured by the North British Locomotive Company, Limited, Glasgow. The first three of 25 of these machines to be made in this country have recently been delivered to Sir Robert McAlpine and Sons, Limited. The machine illustrated is working at the Tramway open-cast coal-mining site, Swanwick, near Ripley, Derbyshire.

When the agreement was arranged it was decided that all parts of the British built excavator were to be interchangeable with the American machine. Unified screws have been used to help achieve this condition and both machines are known as the Lima 1201.

The power unit that is being used is a 4-cylinder Diesel engine made by Crossley Brothers, Limited, Openshaw, Manchester. It develops 240 brake horse-power at a governed speed of 875 r.p.m. The maximum torque is 1,520 lb.-ft. at 600 r.p.m. and this remains practically constant between 500 and 700 r.p.m. The speed of this engine is slightly lower than that of the engine used in the American-built excavator, but as its torque and brake horse-power are greater the use of a suitable gear ratio has enabled the same operating speeds to be obtained.

A 22-in. diameter clutch links the power take-off shaft with the engine flywheel, and these parts are enclosed by a bell-shaped housing. The clutch shaft is extended to carry the main driving pinion. A large radiator incorporating a separate oil-cooling system is fitted and the fan is driven by a belt from the engine crank-shaft. The induction air is cleaned before entering the engine by two oil-bath filters. For starting the engine a compressed-air type of starter has been incorporated, the air being drawn from an air-bottle reservoir. To charge the bottle a single-stage compressor driven by a 3½-h.p. petrol engine is fitted.

The 3½-cub. yd. excavator is one of the first of 25 such machines being produced in this country under licence from the Baldwin-Lima-Hamilton Corporation, U.S.A.

All the major operations performed by the excavator can be directed from the cab by small hand levers and pedals which operate the pneumatic controls. When this machine is required in the form of a crane the upper windows over the front of the cab are cut back to give clear vision of the whole jib when raised. The tracks fitted to the five axles beneath the cab are 44 in. wide, 18 ft. 11 in. long and the width outside the tracks is 13 ft. 1 in. It is said that the flotation and stability of the complete machine when traversing rough ground is extremely good.

Both drag-line and face-shovel booms are controlled by a six-part boom-hoist cable, operated from a fast independent boom hoist, anchored in the machinery base. It is driven by a worm gear and is self-locking. The drive is connected through friction type-clutches. The boom is of the open-lattice design and is built in three sections. The chord angles are made from a specially-selected steel. The length of the standard boom is 80 ft. and it may be reduced to 60 ft. by removing the centre section.

The point sheave is large in diameter, with a wide deep throat. This type of sheave is said to prolong the life of the cable by eliminating all possibility of damage caused when the bucket is swung at a wide angle. As can be seen from the illustration, the dragline machine has a high gantry A-frame which increases the stability of the machine and is of considerable assistance to the operator when the boom is extended to its full working radius. With a boom length of 100 ft. and an angle of 20 deg. the working capacity is 8,060 lb. The dumping radius at this setting is 98 ft., the dumping height 28 ft. and the maximum digging depth 42 ft. When a short boom of 60 ft. is in use at an angle of 45 deg., the capacity increases to 20,000 lb. and the dumping radius becomes 46 ft. 6 in., the dumping height 32 ft., and the digging depth diminishes to 22 ft. Five boom lengths are made and these cover all settings over their full working range between the figures given.

The machine can also be built as a shovel of 3½-cub. yd. capacity and the crane version, which can be fitted with booms from 60 ft. to 120 ft. long, has a lifting capacity from 1,770 lb. up to 124,300 lb.

HEAVY EQUIPMENT FOR POWER STATIONS

Present and Future Trends in Europe

The Organisation for European Economic Co-operation, 2 Rue André-Pascal, Paris, XVI[e], has issued the results of the seventh survey it has conducted into the production of power-station equipment in Europe. This deals with boilers, steam and hydraulic turbines, alternators and transformers, and contains all the information collected on the subject up to April 1, 1954.

The output of boilers with individual capacities between 45 and 180 tons per hour which were installed during the period under review together amounted to 20,468 tons per hour, while that of the larger units was 7,440 tons per hour. These figures did not equal those of the preceding 15 months owing to the decline in the completion of the smaller boilers. It is considered, however, that there will be a record output during the present year, because of the marked increase in demand for very large units. Practically all the large boilers were installed in establishments in the country in which they were manufactured.

STEAM TURBINE DELIVERIES

Deliveries of steam turbines with outputs between 10 and 40 MW decreased to 2,277 MW. On the other hand, those for the larger units amounted to 2,498 MW, which was only slightly below the 1952 figure. On April 1, 1954, the capacity of the small turbines on order was 5,669 MW, which shows a decline since 1951, but this was balanced by orders for the larger units which amounted to 11,641 MW, compared with 9,242 MW three years ago. The position as regards both small and large steam-driven turbo-alternators remains steady, the aggregate capacity of units with outputs exceeding 40 MW being 3,029 MW, compared with 3,094 MW in 1952. On the other hand, the capacity of alternators driven by hydraulic turbines totalled 4,302 MW and established a record, while that of the turbines themselves was 4,757 MW. The capacity of the transformers installed totalled 73,601 MVA.

It is pointed out that from the end of the war until 1952 the production of heavy plant for power stations increased continuously. During 1953 only water-power alternators and transformers showed a decrease, owing to delays in deliveries. This situation is considered to be only temporary, as the demand for hydro-electric plant is decreasing in Europe since most of the economic sites have already been exploited. A further point of interest is that orders for the smaller units of all types of plants have decreased, while those for the larger equipment have risen, except in the case of the steam turbines. In fact, nearly half of the orders for boilers now in hand are for units of capacities exceeding 180 tons per hour.

TECHNICAL DEVELOPMENTS

On the technical side, Europe now produces equipment which is as advanced as any to be found elsewhere. Five countries are manufacturing steam turbines with individual outputs of 100 MW or more, while seven are producing 150-MW transformers. Thermal efficiency has greatly improved, as the result of technological progress in materials, but values are tending to reach an optimum and, without some unexpected developments, present values are not likely to be surpassed for many years.

THE CABLE SHIP "RECORDER"

DESIGNED TO HANDLE CABLE WITH DEEP-SEA REPEATERS

The cable ship Recorder, which left London on her maiden voyage on Thursday, October 21, is the largest and fastest ship of the fleet of Cable and Wireless, Limited. Her designed speed is 12 knots, which is 2 knots faster than the company's other ships. She is interesting from the fact that she is the first vessel of her kind to be designed to handle deep-sea submarine telegraph repeaters. After laying cables in the western approaches to the British Isles she will proceed to Singapore, where she will relieve the cable ship Stanley Angwin, which will be transferred to Gibraltar. She will then be used to maintain the 20,000 miles of cable operated by Cable and Wireless in the Far East.

The vessel, which was built by Swan, Hunter, and Wigham Richardson, Limited, Newcastle-upon-Tyne, has an overall length of 340 ft. 6 in. and a moulded breadth of 45 ft. She is designed to carry a deadweight of about 2,500 tons on a draught not exceeding 18 ft. 6 in. She has been equipped with extra large bow sheaves to facilitate the laying and maintenance of cables which may include submarine repeaters.

The Recorder is propelled by twin screws, which are directly driven by triple-expansion engines. These engines are installed aft and are designed to develop a total of 2,200 h.p. when supplied with steam at a pressure of 220 lb. per square inch from two multi-tubular Scotch boilers. Oil firing under forced-draught conditions is employed.

Auxiliary power is obtained from three 100-kW sets which generate direct-current at 220 volts. Two of these sets are driven by steam engines, manufactured by Belliss and Morcom, Limited, Birmingham, and one by a Diesel engine, supplied by the National Gas and Oil Engine Company, Limited, Ashton-under-Lyne. The electrical installation was carried out by Campbell and Isherwood, Limited, Newcastle-upon-Tyne, and is arranged for parallel operation. The main and auxiliary cables in the machinery spaces, holds and galleys are insulated with Pyrotenax.

CABLE GEAR

The oil-fuel tanks are arranged immediately forward of the propelling machinery and forward of them again are the cable storage tanks. The total coiling capacity of the latter is about 21,000 cub. ft., thus providing accommodation for some 420 nautical miles of deep-sea cable. The forward hold and 'tween decks are arranged for the storage of buoys and cable gear.

As will be seen from the illustration, two cable gears are installed abreast on the forward main deck. These gears, which were manufactured by Johnson and Phillips, Limited, Charlton, London, are of that firm's well-known standard pattern. They are driven by engines supplied by W. Sisson and Company, Limited, Gloucester, which are operated by live steam and are controlled from the deck above. The gears are fitted not only with direct-acting wood and water-cooled steel band brakes, but with a hydraulic brake, which was manufactured by Heenan and Froude, Limited, Worcester.

The cable gear equipment is completed by bow and span lead sheaves, the former being mounted on the clipper stem, as well as by the usual dynamometers. An electrically-driven winch for turning over the cable in the tanks is also installed. Other plant comprises a steam-driven capstan windlass on the upper deck which is used for driving the combined cable lifters and capstan heads, steam-driven winches for serving the 3-ton derricks on the fore deck, and steam-driven warping capstans aft.

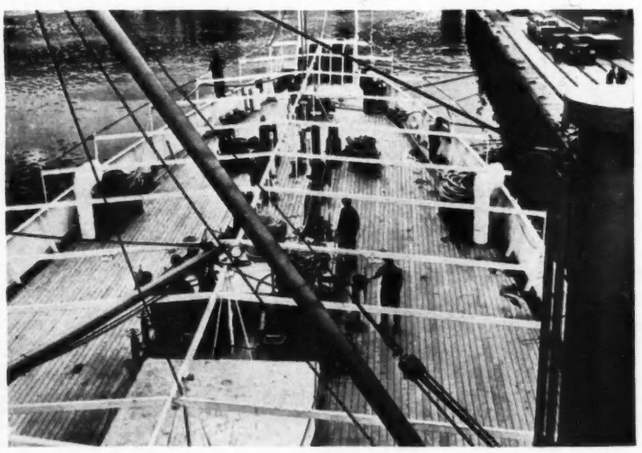
TESTING EQUIPMENT

The Recorder is equipped with a complete set of the cable testing apparatus which is necessary for her to carry out the duties for which she was designed. This is all of the high-precision type and was supplied principally by H. W. Sullivan, Limited, Peckham, London, S.E.15, the ancillary equipment being manufactured by Muirhead and Company, Limited, Beckenham, Kent, and Gambrell Brothers and Company, Limited, Purley-way, Croydon.

A comprehensive radio installation has been supplied by the Marconi International Marine Communication Company, Limited, Chelmsford, and consists of an Oceanspan transmitter embodying both radio telegraph and telephone facilities and incorporating a Worldspan amplifier. It is designed to operate in conjunction with Mercury and Electra superheterodyne receivers. There is also an emergency watch receiver with an automatic keying unit.

The installation further includes three portable transmitter/receivers, which will enable short-range speech communication to be maintained between the ship and repair and maintenance parties in boats or on shore. To ensure safety of life at sea, Seaguard auto-alarm and a Salvita portable lifeboat radio transmitter/receiver are provided, while a Lodestone long-range direction finder is fitted to aid navigation.

Echo sounders of both the deep-sea and shallow-water types have been installed by Kelvin and Hughes (Marine), Limited, 99 Fenchurch-street, London, E.C.3, while the navigating equipment includes a 5,000-fathoms Lucas sounding machine with electric drive, which was manufactured by the Telegraph Construction and Maintenance Company, Limited, London.



The fore deck of the Recorder showing the cable gear. This deck has been made specially wide so that repeater cable can be handled.

CONTROLLING FLAME FAILURE

Automatic Electronic Protection for Gas-Fired Equipment

A recent addition to the range of electronic flame-failure equipment for gas-fired installations, the fully automatic F.S.5.M. control, manufactured by Elcontrol Limited, 10 Wyndham-place, London, W.1, has been pronounced by the North Thames Gas Board to satisfy their requirements for such equipment and to be of robust construction, eminently suitable for heavy industrial use where a quick response and the most complete degree of automatic protection is required.

The F.S.5.M. flame-failure control unit is designed for forced-draught installations in which the fan is controlled by an air-flow switch, with main and pilot burners controlled by magnetic gas valves and with automatic high-tension spark ignition. The unit provides automatic safe ignition on lighting up, immediate fuel cut-off should the flame fail during running, automatic safe re-ignition after flame failure, and automatic lock-out should the gas supply or any part of the control equipment fail.

The controller consists of a system of relays and electronic circuits grouped in a control unit, shown in the accompanying illustrations with the cover plate removed, and a quick-release viewing head screwed on to a standard 2-in. pipe attached to the burner front plates and disposed so as to view the pilot flame. The viewing head comprises a lead-sulphide cell sensitive to infra-red radiation from all types of flame, but its circuit is so arranged that it does not respond to steady radiation from a white-hot refractory, etc.

In the control unit, all the electronic circuits and relays are mounted on a chassis which is quickly removable by disconnecting the mains plug in the top right-hand corner, the viewing head connector in the left-hand corner, and removing four attachment screws. This feature greatly facilitates servicing. In the upper illustration which shows the chassis removed, it can be seen that there is a second mains socket on the right-hand corner of the housing. This provides for immediate manual control should it be necessary to remove the automatic-control chassis when there is no spare equipment available. Also accessible on the back of the chassis is a two-position switch which can be set either for automatic re-cycling—i.e., automatic re-ignition after flame failure—or for " lock-out " after flame failure.

The Elcontrol F.S.5.M. automatic flame-failure control uses an infra-red sensitive cell responsive to flame, but not to steady radiation from white-hot refractories. It provides automatic safe ignition and re-ignition after flame failure, immediate fuel cut-off at flame failure, and automatic lock-out in the event of any equipment failure.

The control-unit chassis on which the relays and electronic circuit are mounted is easily removed and replaced.

The method of operation of the automatic control unit is as follows. Before it can be set in operation, the mains switch supplying power to the control unit and its associated circuits as well as the fan starter must be on. On the control unit itself, the gas on-off switch is turned on.

When the fan is working normally, the air-flow switch is actuated through a magnetic relay, bringing into operation a time switch which does not close until a pre-set purging time, adjustable between 1 and 10 minutes and normally set for about 3 minutes, has elapsed. This ensures that any accumulations of unburnt gas are purged from the system before ignition is started. During this period a " purging " indicator light is illuminated.

At the end of the purging time, the time-switch-operated relays open the pilot gas valve and bring the ignition transformer into the circuit. The spark is held on automatically for 10 seconds, during which the " ignition on " lamp is illuminated. At the end of this period the pilot jet should have ignited and should be sensed by the radiation head, bringing the electronic control unit into action, opening the main valve, and holding open the pilot valve. At the same time a " flame on " indicator lamp is lighted.

Should the pilot flame fail to be established during the " ignition on " period, the pilot valve will close automatically and a " no flame " warning light will come on, and remain on, until a reset push-button on the control unit is operated to re-initiate the whole purging and ignition cycle.

If the flame should fail during normal running, the electronic control circuit will be broken and within less than ½ second both the main and pilot gas valves will be shut off. If the cycling switch has been pre-set to the re-cycle position, the ignition cycle will be immediately restarted, but without the purging period, now unnecessary since there is no accumulation of unburnt gas. If this does not re-establish the flame, both gas valves will remain closed and the " no flame " indicator light will be illuminated. When the re-cycling switch has been pre-set to the " non-re-cycle " position, the apparatus " locks out " immediately upon flame failure. Operation of the reset push-button then initiates the full ignition cycle including purging.

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LAUNCHES AND TRIAL TRIPS

M.S. " MORGENEN."—Single-screw oil tanker, built by Sir James Laing and Sons, Ltd., Sunderland, for A/S Tanktransport (Manager: Thorvald Berg), Tonsberg, Norway. Main dimensions: 512 ft. between perpendiculars by 72 ft. 6 in. by 41 ft. 2 in.; deadweight capacity, 18,300 tons on a summer draught of about 30 ft. 6 in. N.E.M.-Doxford six-cylinder opposed-piston oil engine, constructed by the North Eastern Marine Engineering Co. (1938), Ltd., Wallsend-on-Tyne. Speed, 14¾ knots. Launch, September 27.

M.S. " BARRISTER."—Single-screw cargo vessel, built and engined by William Doxford and Sons, Ltd., Sunderland, for the Charente Steam Ship Co., Ltd. (Managers: Thos. and Jas. Harrison, Ltd.), Liverpool. Second of two similar vessels. Main dimensions: 464 ft. overall by 59 ft. 6 in. by 37 ft. 8 in.; deadweight capacity, about 9,700 tons. Doxford four-cylinder opposed-piston oil engine. Service speed, 13¼ knots. Delivered, September 28.

H.M.S. " PELLEW."—Anti-submarine frigate, built by Swan, Hunter, and Wigham Richardson, Ltd., Wallsend-on-Tyne, for the Admiralty, London, S.W.1. Length, 310 ft. overall; beam, 33 ft. Armament comprises three Bofors guns and two three-barrelled anti-submarine mortars. Propulsion provided by geared steam turbines constructed by the Wallsend Slipway and Engineering Co., Ltd., Wallsend-on-Tyne. Launch, September 29.

H.M.S. " AXFORD."—Seaward defence boat, built by Wm. Simons & Co., Ltd., Renfrew, for the Admiralty, London, S.W.1. Length, 117 ft. 3 in. overall; beam, 20 ft. An entirely new design of vessel propelled by Diesel engines, her armament includes small guns. Launch, September 30.

SHIP No. 495.—Grain-elevating pontoon, built by the Goole Shipbuilding and Repairing Co., Ltd., Goole, for the Ministry of Transport and Civil Aviation, London, W.1. Main dimensions : 87 ft. by 37 ft. 6 in. by 15 ft. Trial trip, October 11.

M.S. " AGHIOS NICOLAOS."—Single-screw cargo vessel, with accommodation for a small number of passengers, built and engined by William Doxford and Sons, Ltd., Sunderland, for the Porto Blanco Compania Naviera S.A. (Managers: Rethymnis and Kulukundis, Ltd.), London, E.C.3. Second vessel of a series of three. Main dimensions: 450 ft. between perpendiculars by 62 ft. by 30 ft. 6 in.; deadweight capacity, about 11,100 tons. Doxford four-cylinder opposed-piston oil engine. Service speed, about 13¾ knots. Launch, October 11.

LIGHT VESSEL No. 17.—Built by Philip and Son, Ltd., Dartmouth, for the Corporation of Trinity House, London, E.C.2. Twenty-fifth light vessel constructed for the Corporation. Main dimensions: 130 ft. by 25 ft. by 15 ft.; gross tonnage, 350. The lantern contains six 500-watt lamps, giving a beam visible for from 10 to 12 miles in clear weather. Launch, October 11.

S.S. " ROLLO."—Single-screw cargo vessel, with accommodation for twelve passengers, built by Henry Robb, Ltd., Leith, for the Mediterranean and Scandinavian trade of Ellerman's Wilson Line, Ltd., Hull. Second of two ships for these owners. Main dimensions: 290 ft. between perpendiculars by 48 ft. 6 in. by 27 ft. to upper deck; deadweight capacity, about 2,400 tons on a mean draught of 17 ft. 9 in. Triple-expansion direct-acting marine reciprocating engine working in conjunction with a Bauer-Wach exhaust steam turbine through single-helical reduction gearing. Steam supplied by two multitubular oil-fired boilers. Main engine constructed by Swan, Hunter, and Wigham Richardson, Ltd., Newcastle-upon-Tyne; and the exhaust turbine, gearing and boilers by Barclay, Curle & Co., Ltd., Glasgow. Service speed, 13 knots. Delivered, October 12.

BRUNSWICK WHARF POWER STATION

INDOOR 132-KV AIR-BREAK SWITCHGEAR ADOPTED WITH 330-MW PLANT

Concluded from page 529

Each 52·5-MW alternator, which generates three-phase current at 11·8 kV when running at 3,000 r.p.m., is solidly connected to a 55·55-MVA 11·8/134-kV Metropolitan-Vickers transformer, which is provided with on-load tap changing equipment. It is also connected through removable links to a 5-MVA 11·81/3·3-kV unit transformer from which a supply is given to the station auxiliary plant. The arrangements on the 60-MW sets will be similar. Supplies to the auxiliary plant are also available from the two 10-MVA 132/3·3-kV station transformers, the high-tension sides of which are connected to the main bus-bars, though a 415-volt supply can be given to certain auxiliaries through 0·75-MVA 3·3-kV/415-volt transformers. All these auxiliary transformers were manufactured by Johnson and Phillips, Limited, Charlton, London, S.E.1.

The main and station transformers are installed in outdoor compounds. Most of the unit transformers are housed in rooms forming an electrical auxiliaries annexe along the north wall of the turbine room, but the 0·75-MVA transformers from which a supply is given to the coal-handling and the ash and dust removal plant are located near the motors which they serve.

MODERN SWITCHGEAR DESIGN

The 132-kV switchgear, which was manufactured at the Willesden works of the British Thomson-Houston Company, Limited, provides an example of the modern practice of installing equipment operating at this voltage indoors. Compared with the low-level outdoor switching stations which now form a familiar part of the grid equipment this leads to a considerable saving in the space occupied. In fact, only about 1,400 sq. ft. per circuit as against 6,000 sq. ft. is required. It is true that with the high-level type of grid switching station the area taken up is about 2,500 sq. ft., but such switchgear is difficult to clean and maintain, especially in comparison with indoor equipment.

The circuit-breakers in use at Brunswick Wharf are of the air-blast type and have a rupturing capacity of 2,500 MVA at 132 kV. Their appearance will be clear from Fig. 3. Each phase includes two blast heads, one of which is shunted by a linear resistor. The heads are mounted on separate local air receivers which are supported on post insulators, these insulators being attached to a common fabricated steel base. The two blast heads are coupled together by a series air-break switch, two breaks in series being provided. The contacts are of the silver-faced spring-loaded butt type. They are air operated from the local air receivers, the short passage provided by this construction ensuring a high operating speed.

When the breaker is opened air is admitted through the blast valves to the blast heads so that the contacts are forced apart and the current is interrupted. The series air-break switch then opens, the blast valve closes and the main contacts are re-closed, leaving the circuit interrupted. The breaker is closed again by operating the series switch, the contacts of which are designed to make and carry the short-circuit current.

The isolators and bus-bar selector switches are of the centre rotating-post types with two horizontal breaks. They are equipped with replaceable high-pressure line contacts and are mounted on welded steel-tube bases. They are operated manually through vertical shafts, bevel gearing and rods. Switches are provided for earthing the terminals of the 132-kV cables and both sides of each circuit-breaker so that cleaning and maintenance can be safely carried out. The post insulators are of the conventional outdoor cap and pin type, as is illustrated in Fig. 4, while the floor bushings are of the solid paper-insulated condenser pattern.

LAYOUT ARRANGEMENTS

As regards layout, a conventional duplicate bus-bar scheme has been adopted with a bus section breaker in the main bars and bus section isolators in the reserve bars. At present, nine units are in use, although 21 will be required when the station is completed. The switchgear is housed in a separate three-storey building with the bus-bars and selector switches on the two upper floors and the circuit-breakers, isolators and earthing switches below. The circuits are grouped in pairs, each pair having a common length of bus-bar to secure the maximum economy in floor space. All the high-voltage connections between the upper and lower floors are taken through bushings, so that the various sections are segregated.

The bus-bars, which consist of hard-drawn copper tube, are suspended from post insulators bolted to the ceilings and are separated from each other by brick partitions with screens and interlocked doors.

COMPRESSED AIR EQUIPMENT

Air for operating the circuit-breakers is obtained from three-stage motor-driven compressors supplied by Reavell and Company, Limited, and Broom and Wade, Limited. These deliver air at a pressure of 450 lb. per square inch to receivers which are equipped with refrigerator units for drying. The air is next passed through diaphragm valves, which reduce the pressure to the operating value of 260 lb. per square inch, to storage receivers. The compressors are normally controlled by switches on the high-pressure side of the reducing valves and provision is made for locking out a circuit-breaker if the receiver pressure falls below 200 lb. per square inch. These receivers are, in turn, connected through a ring main of solid-drawn copper tubing from which spurs are taken through stop valves to the individual circuit-breakers. Dry, clean air is supplied to all the 132-kV switchgear compartments from an automatic humidity-controlled conditioning plant.

MAINTENANCE ARRANGEMENTS

Comprehensive arrangements have been made for maintaining the 132-kV equipment in the station. In the case of the bus-bars and their supports, this work is done from cages which are suspended on wheeled trolleys from iron runways. These cages are manually operated and enable a man with his tools to travel the complete length of the bus-bar to check the insulators and connections. The bus-bar selector switches which are at ground level are enclosed in a locked frame so that access to them is only obtainable when the equipment is dead. The blast heads and contacts of the circuit-breakers can be removed by blocks and tackle after they and the associated cable sealing ends have been earthed. This earthing is effected by switches which are interlocked with the doors of the breaker compartments.

The 132-kV switchgear is controlled from a room overlooking the turbine house, the board being of the conventional sheet-steel cubicle type with a mimic diagram and electrically-operated semaphores. Control apparatus and instruments for the generators are mounted on desk-type panels, as is the annunciator equipment which gives warning of faults.

The 3·3-kV auxiliary switchgear was manufactured by the English Electric Company, Limited, Kingsway, London, W.C.2. It is also of the air-break type and has a short-circuit rating of 150 MVA. The low-tension switchgear was supplied by the same firm.

Fig. 3 Aerojet air-blast circuit-breaker which has a rupturing capacity of 2,500 MVA at 132 kV.

Fig. 4 132-kV air-break rotating-post isolators.

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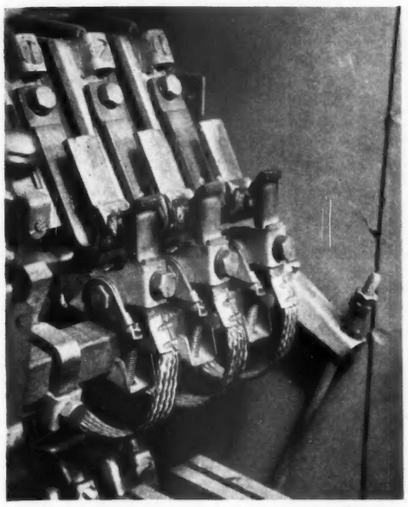
CONTINUOUS ELECTRODE FOR AUTOMATIC ARC WELDING

Murex Welding Processes, Limited, Waltham Cross, Hertfordshire, have developed a continuous electrode. This is intended for use with all types of direct-current automatic welding machines which have been designed for continuous coated electrodes. The new electrode, which is known as "Coilex," is double wire wound and flux extruded. It can be used for either butt or gravity fillet welds on all classes of steel work, but, as the flux is of the basic type, it can also be employed for welding "difficult" steels or making joints in mild steel under conditions of contraction restraint. Its rate of deposition is high and its penetration deep; it also has a consistent "burn-off", good weld appearance and easy striking.

To ensure robustness the outer wire winding of "Coilex" is applied with a series of definite "sets" so as to form a number of minor projections above the surface of the extruded flux. Good electrical contact with the jaws of the welding head can thus be maintained, while, as a greater quantity of flux can be more firmly held to the core wire, splay at the arc is reduced.



The sintered tungsten-silver contacts shown here have been in use for 3½ years without attention. They control an inductive load involving many "inching" movements.

LOW-VOLTAGE CONTACTORS

Sintered Tungsten-Steel Contacts Used on Heavy-Duty Control Gear

A range of low-voltage contactor gear is being marketed by G.W.B. Furnaces, Limited, Dibdale Works, Dudley, Worcestershire, in which the contacts are made of sintered tungsten-silver. This design was developed by Officine Meccaniche Riunite of Milan, and it is claimed to have a life twenty times that of copper contacts. Contactors are available for ratings up to 1,400 amperes, with voltages of 550 (alternating current) or 600 (direct current). The illustration shows a set of these contactors which have been in service for 3½ years in an application involving a large number of "inching" movements.

In addition to their resistance to arcing and mechanical wear, the sintered contacts are highly resistant to corrosion. It is therefore possible for this gear to be used in the highly corrosive atmospheres that are met in marine applications and in chemical engineering. It is also claimed that the rating does not have to be decreased as the number of operations per hour is increased, and that therefore it is frequently possible to use a smaller size than would be needed if copper faces were being used. The contactor arm is pivoted in hardened steel points which have shown no wear when subjected to over 10 million operations. This equipment lends itself to the construction of built-up panels, and can be fitted with such auxiliary contacts as may be required.

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GRID ROLLER

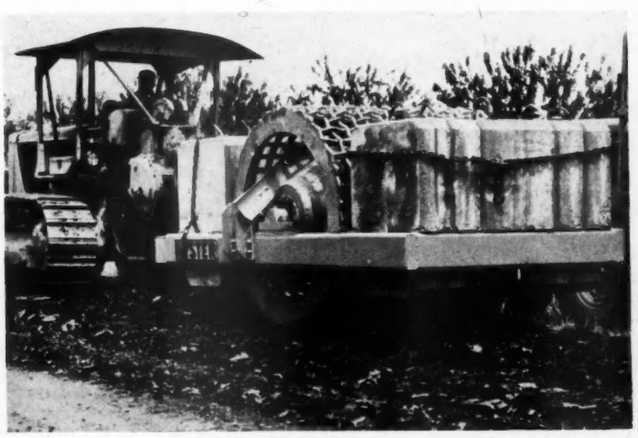
Salvaging Bituminous Material and Compacting Fill in Depth

A new design of grid roller for salvaging bituminous highways and compacting all types of earth fills has been announced by the Hyster Company, 2902 N.E. Clackamas-street, Portland 8, Oregon, U.S.A. The rolling of over-optimum fills and wet spots has been made practicable by the addition of a mechanical cleaner which removes any wet material that enters the roller. The first grid roller developed by this company in 1952 made possible economical salvaging of aggregate and binder from asphaltic pavements by quickly crushing and reducing to size all asphaltic material after ripping. Savings could then be effected by re-using this material when laying new road surfaces.

For compaction the advantages claimed are high-speed rolling and higher densities in fewer passes. When crushing pit-run material directly on the subgrade, the machine builds a firm base by crushing and compacting simultaneously. Secondary roads can therefore be built economically with a firm surface which resists water penetration and erosion.

On the new roller an outer wheel-plate can be removed and replaced by a cone-shaped core and cleaner blade mounted on the frame as shown in the illustration on this page. The blade rapidly removes wet material and is easily adjusted to compensate for blade wear. The tow bar coupling is made for drawbar pins and yokes of various dimensions and heights above ground, and a pivoting tongue is used to change the tracking position of the roller behind the towing vehicle. Three adjusting holes provide for tracking directly behind or 14 in. to either side of a tractor. A jack leg which can be retracted is fitted to the tow bar; this serves as a support after uncoupling. An adjustable roll scraper, which can be easily replaced, is mounted underneath the frame behind the rollers. The grids are cast from alloy steel and heat treated. Each segment has the appearance of woven open-mesh made by interlacing 1½-in. bars on 5-in. centres. The opening between the bars is 3½ in. by 3½ in. and the surface hardness of the material used is about 300 Brinell.

The net weight of the roller and frame is 12,400 lb. and the gross weight, including ballast and cleaner, is 30,000 lb. The ballast weights are T-shaped and are made of concrete set with reinforcing bars.



The grid roller has many advantages when compacting soil fills in depth and for salvaging asphalt surfaces. The cone-shaped wheel plate ejects wet material entering the roller and the blade fitted to the chassis frame cleans the cone wheel as it rotates.

ELECTRICITY SUPPLY IN NEW ZEALAND

Satisfactory Hydro-Electric Developments

The annual statement of Mr. W. S. Goosman, Minister-in-Charge of the New Zealand State Hydro-Electric Department, shows that during the year ended March 31, 1954, development in electricity supply followed a satisfactory course. The only difficulty seems to have been to keep pace with the ever-increasing demand which is being experienced in that country as in other parts of the world.

In the North Island 2,758 million kWh were generated for public supply, an increase of 15·4 per cent. over the figure for the previous year. In the South Island the output was 1,156 million kWh, an increase of 6·8 per cent., while in the Nelson-Marlborough area it was 114 million kWh, an increase of 8·6 per cent. The maximum demand in the North Island was 567 MW, the corresponding figures for the South Island and for the Nelson-Marlborough area being 226 MW and 19 MW. Hydro-electric, steam and Diesel plant were all employed, although the first was predominate.

The Maraetai station in the North Island came into full operation during the year, while construction proceeded at four other stations and that at two others is envisaged. An interesting project is the building of a geo-thermal station at Wairakei, which it is hoped to complete as soon as possible in order to supplement the hydro-electric stations.

At Waitaki in the South Island two 15-MW sets were commissioned and work is proceeding, or will shortly be begun, at five other stations. At Cobb, two 10-MW sets have been installed, but as the dam is not yet complete temporary control sluices have been installed to allow one of these sets to be run.

Good progress was made with extensions to the transmission system. A second 220-kV line was erected between Whakamaru and Otahuhu and work was continued on the Whakamaru-Bunnythorpe section. The first portion of the 220-kV Roxburgh-Islington line in the South Island was also brought into operation at 110 kV. It is being used to transmit power from Tekapo to North Canterbury in preparation for the operation of the new machines at Waitaki. A 220-kV substation was placed in operation at Haywards, while the commissioning of the 110-kV substation at Islington will improve the supply to Canterbury.

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TRENCH DIGGING MACHINE

Excavating for Outfall Sewers

A trench-digging machine which, it is claimed, will be the world's largest is being designed by Gar Wood Industries, Wayne, Michigan, U.S.A. In spite of its size, 81 ft. long, 15 ft. high and 12 ft. wide excluding the discharge conveyor, it is estimated that the final cost of this machine will be less than that of conventional excavating equipment for the capacity to be obtained. The finished weight is expected to be around 65 tons.

The digging end will be mounted on crawler tracks and the forward end will be supported by rubber-tyred wheels. Two Diesel engines fitted with torque-convertor drives will supply power to the tracks and to the bucket drive. Hydraulic power-assisted steering will be used.

The excavator is intended primarily for digging intercepting and outfall sewer trenches, water-diversion aqueducts and other large ditches. The designer's concessionaire in Great Britain is Mackay Industrial Equipment, Limited, Feltham, Middlesex.

STIFFENED-PANEL CONSTRUCTION WITH LIGHT ALLOYS

FABRICATION OF TRANSPORT UNITS

The combination of the frame and cladding—monocoque construction—for any type of structure offers a potential saving in material as a fuller use is made of the properties of the skin or cladding. For all forms of transport vehicle, the reduction in the deadweight obtained by the employment of " stressed-skin " designs leads to higher payloads and more economical working. The further combination of monocoque construction with the use of light alloys, which of themselves are low in weight, have adequate strength, and for which maintenance costs are low, permits transport vehicles to be built with many advantages over ordinary models. The development of the inert-gas (argon-arc) welding processes and the relegation of riveting to a secondary role in vehicle construction has done much to bring about the changes already described, but the use of extruded stiffened planks of the types illustrated in the drawing and in the accompanying pictures has enabled the method of construction to be brought to its present level.

The planks already mentioned are large flat extruded sections in which the skin or facing for a structure or bodywork is combined with the structural framing or stiffeners. A number of these planks are then welded together to form larger areas or " panels," there being no practical limit to the size of panel that can be fabricated without the use of a rivet; for example, the complete side of a furniture van can be made in one piece, stiffeners and skin combined.

The maximum width for a plank is normally 12 in. and the thickness of the skin varies from $\frac{3}{32}$ in. upwards according to the width of the plank and the alloy from which it is made. Some typical profiles of plank sections are shown in the drawing. The extrusion process permits the metal to be distributed so that sectional strength is obtained economically; fillets, bulbs, bolt grooves, corner pieces, etc., can easily be incorporated and, where circumstances require, it is possible to arrange for stiffeners to be disposed so that it is easy to attach internal linings and insulation using " invisible " bolts.

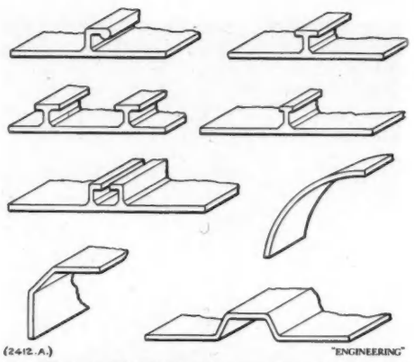
WELDING METHODS

Maximum exploitation of these light-alloy panels is largely dependent upon a suitable welding process. Oxy-acetylene and the earlier forms of arc-welding had the disadvantage that it was necessary to use a chemical flux to dispel the formation of oxides during the welding operation. The flux was corrosive in nature, hence it was very necessary to ensure that joints were free from flux inclusions and that all traces of the flux were washed away from the surface of the metal when welding was completed. Another disadvantage, particularly when gas-welding thin sections, was that the heat dissipated into the surrounding metal often caused undue distortion and, in some cases, loss of strength in the metal in areas adjacent to the joint.

In the new arc-welding techniques, the molten pool is shielded from oxidation by an inert gas, argon. As no flux is used, flux-contamination and after-weld cleaning are eliminated. The strength of the metal near to the joint is retained at a much higher level and there is not such extensive distortion because the heat is more localised.

Two variants of the argon-arc welding process are used. In the basic process an arc is struck between the aluminium and a tungsten electrode projecting from the welding torch. This arc is shrouded by a stream of argon introduced through the torch and around the electrode. Additional filler metal is hand-fed into the molten pool from an uncoated filler rod, though mechanical feed devices can be used for particular purposes. This basic process is suitable for welding metal up to $\frac{1}{4}$ in. thick.

Where heavier sections of metal are to be joined, the tungsten electrode is replaced by an aluminium filler wire which is automatically and continuously fed from the torch into the weld pool. Higher welding currents can be employed and greater welding speeds can be attained even on the thicker sections; the process is particularly amenable to the use of fixtures and controls which enable long straight runs—such as are required with stiffened-panel fabrication—to be carried out automatically.

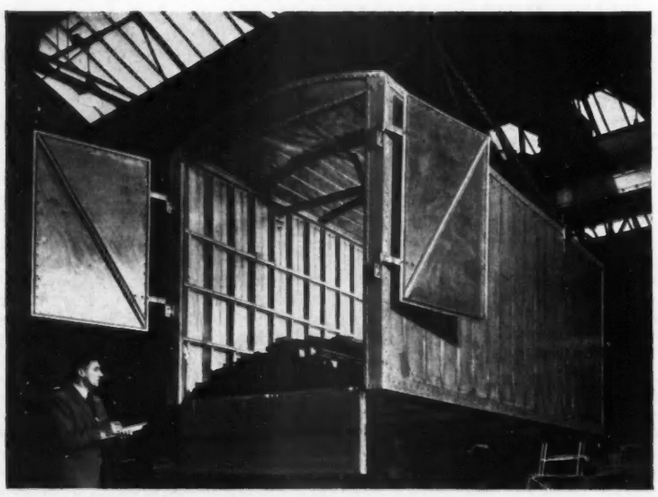


Typical extruded light-alloy sections or " planks." By welding a number of planks together side by side, stiffened panels can be made which combine the properties of framing and cladding.

ROAD AND RAIL CONTAINERS

Stiffened-panel construction has an immediate application in the construction of containers of the type used by the railways for the door-to-door bulk transport of goods, or by the road-haulage industry for the conveyance of meat or goods difficult to pack and handle. The rail containers are likely to suffer more wear and tear than do the road containers and therefore require to be more robust, but insulation (for perishable goods) is frequently a feature common to both.

A normal rail container—of steel, or of timber with steel reinforcement—weighs up to 40 cwt. unladen. Made from light-alloy stiffened panels it becomes practicable, as is shown in one of the illustrations, to build a container of the same capacity to weigh only 13 cwt. The container sides, 16 ft. long by nearly 8 ft. high, are each made from a single panel, cladding and stiffeners combined, by simply welding together a number of planks. In the same way, the floor is made as a single unit from



The road-rail container built of light-alloy stiffened panels has a capacity of 630 cub. ft. and a payload of 5 tons for a self weight of only 13 cwt. It is shown here under test, being slung by chains and loaded with 6 tons of steel sections.

Section of a barge being built up from extruded sections and stiffened panels of light alloy. The panels have been fabricated from the planks by welding, though riveting has been used to join the side panels to the bilge corners.

planks 16 ft. long with the stiffeners running from end to end, though in this case strengthened by the use of cross bearers. The solid end is constructed in a similar fashion, as is also the drop board. Doors are readily fabricated from panels with an outer framing, or may be of conventional design using plain sheet and framing. The roof is built from ribbed aluminium sheet laid over extruded sections.

The container illustrated is carrying a test load of 6 tons of steel sections; though the container was then being carried by the chain slings alone—that is, without the use of stretcher bars—the greatest approach between the two sides was only 0·06 in. Neither, it will be observed from the illustration, has it been necessary to use diagonal bracing from the lifting eyes to the bottom corners of the containers as is usual with conventional construction. The particular container illustrated is intended for the transport of furniture and has neither lining nor insulation—only rubbing strips to give protection to the bodywork and contents during travelling.

BARGE CONSTRUCTION

An example from a different field is that of barge and ship construction. Here many of the advantages are the same as for the road and rail containers. The second picture shows sections being employed in the fabrication of 77-ft. barges. In this instance the shipbuilders themselves welded the stiffened planks to form the large panels later to be assembled in the barge sections. The sides and bilges were built up from welded planks with added stiffeners, the corners of the bilges being special extrusions with a joggled edge to which the side panels were to be riveted. Special sections were used for the keel, hatch coaming and the other structural features.

Four advantages are claimed for light alloys in ship construction: a saving in weight; a resistance to deterioration; non-magnetic properties; and a good clean appearance. The saving in weight may mean either an increased cargo-carrying capacity and increase in stability, or the same stability for a smaller beam; it may permit a reduction in displacement with a consequent economy in engine power required. The resistance to deterioration giving a reduced maintenance charge offsets the higher initial cost, and for tropical waters, where timber hulls are liable to attack by marine borers, light alloys are the equal of steel for obviating this particular difficulty. For deckhouses and bridges, the absence of magnetic properties offers immediate advantages. Care must be taken, however, to avoid the junction of aluminium with a dissimilar metal at points where moisture and particularly sea water, may gain access, or damage by galvanic action may occur.

WEATHER-PROOFING

Finally, the aluminium-magnesium-silicon types of alloys have good weathering properties and may be used out of doors in the unpainted condition, the natural appearance of the metal being sufficiently pleasing, and its oxide film sufficiently protective for many uses and circumstances. When added protection is required in very corrosive conditions, however, a paint can be added in the conventional way as long as the parent surface is adequately cleaned and a suitable etch primer is applied before painting.

For the information on which this article is based we are indebted to T.I. Aluminium, Limited, Tyseley, Birmingham, who are manufacturers of the extruded sections.

SCRAP METAL BALING PRESS

Hydraulic Operation

A press for baling scrap metal, which is smaller than the machines in the maker's present range, has been introduced by Fielding and Platt, Limited, Gloucester. This machine, which is known as the S.C.B.1, is shown in the accompanying illustration. It is self-contained and is hydraulically operated. Light sheet-metal scrap can be compressed into bales of about 12 in. by 8 in. by from 6 in. to 18 in. long, depending upon the quality of material, at a rate of about 35 to 40 bales per hour. The weight of such a bale would be anywhere between ¼ and 1 cwt. Unskilled labour, it is stated, can operate the machine.

The main frame of the baler is fabricated from heavy mild-steel plate. The pump and motor are mounted at one end, with the hydraulic reservoir on stilts above, and the press at the other. The initial compression of scrap, which is laid on the bed as shown in the illustration, is effected by a box-shaped press which measures approximately 36 in. long by 12 in. by 12 in.; when closed the internal depth is 8 in. The lower edges of the three-sided box are fitted with guillotine blades which slide past serrated blades on the bed as the box closes, cutting off any overhanging scrap. To prolong the life of the box it is lined with alloy-steel plate which can be renewed from time to time.

The press is raised and lowered by a hydraulic cylinder which rests in a spherical seating and is attached by trunnions to the top left-hand corner of the box. The pivoting axis is directly beneath the trunnion.

The final compression of the bale is completed, after the box is lowered, by a second hydraulic cylinder which drives a platen attached to the ram head through the box to press the scrap against a substantial door at the discharge end. When the bale is finally compressed the door is opened and the bale ejected by a secondary movement of the ram. The door release mechanism can be arranged for manual or hydraulic operation. The face of the platen is protected by an alloy-steel wearing plate.

The pistons used in the rams are made of cast iron and fitted with Clupet integral rings. The ram packings are of the automatic type requiring no adjustment. Sleeves of treated leather in the form of bellows protect the piston rods from dust and abrasion.

The pressure for operating the rams is provided by a two-stage radial pump giving a maximum delivery of 2·25 gallons per minute at 2 tons per square inch. The specific pressure exerted on the scrap is about 30 tons per square foot.

The squirrel-cage motor used for driving the pump is rated at 8 h.p. at 940 r.p.m., and is normally wound for a 400-volt supply. It is controlled by a star-delta starter. The control valves for the box and bale rams are operated by the hand levers which are mounted on the sides of the box frame. The reservoir has a capacity of about 35 gallons and the flow to the pump can be cut off by a low-pressure isolating valve in the pipeline.

A larger version of this machine, the S.C.B.2, is also being made for compressing bales of 1 to 2 cwt. at a speed of about 26 to 30 bales per hour.

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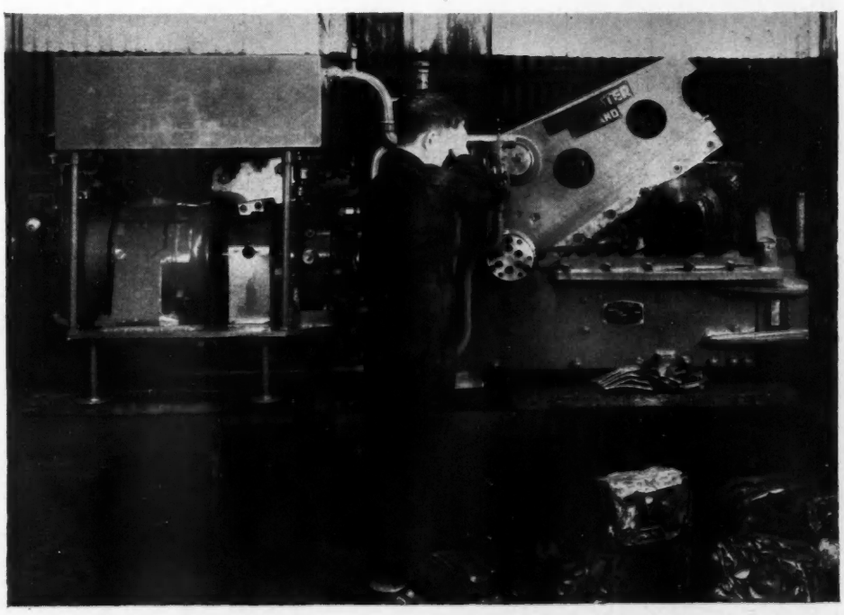
THERMOMETER-TUBE DRAWING TOWER

Electronic Control

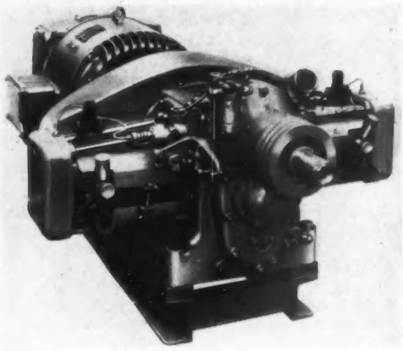
A 130-ft. high electronic tube-drawing tower for the production of clinical-thermometer tubing has been erected at the Whitefriars glassworks of James Powell & Sons, Limited, Tudor-road, Wealdstone. The only structure of its kind in the country, the tower was conceived by Mr. W. J. Wilson, the company's managing director, and Mr. C. H. Cooper, technical director. It was constructed by Pirelli General, Limited, Southampton.

The height and speed of the draw are controlled by electronic equipment and motors housed at the base of the tower, which is lit for night-climbing. It is equipped with four drawing trolleys which, by means of wires, hoist the molten glass from the four billets anchored at the foot of the tower. When a trolley has drawn the thermometer tubing to the required height, the operator regulates the trolley's drop in stages so that the tubing can be cut into "canes" of convenient length.

The new tower has improved the quality of the clinical thermometer tubing produced, and waste has been eliminated. Clinical thermometer tubing—a valuable British export—was formerly produced at Whitefriars by means of the horizontal hand-drawn method.



Bales of scrap sheet and strip metal from a ¼ to 1 cwt. can be produced by this hydraulically-operated baling machine at a rate of 35 to 40 bales per hour.



Horizontally-opposed twin-cylinder air-cooled Diesel engine with 9-kW generator. A water-cooled version of the engine is particularly suitable for marine uses.

TWO-CYLINDER DIESEL ENGINE

Air-Cooled and Water-Cooled Versions

The small two-cylinder engine which is illustrated above is of the compression-ignition type and, as can be seen, the cylinders are horizontally opposed. It is known as the Vixen, and has been introduced by the Coventry Victor Motor Company, Limited, of Coventry, who are displaying four different variants of this new model at the International Motor Exhibition now being held at Earl's Court, London. The four versions comprise two sizes, one of 1,292 c.c. capacity and the other of 1,440 c.c., both of which are available with water cooling or air cooling.

The air-cooled model, which is shown in the illustration, is coupled to a 9-kW generator to form a simple power pack. The power take-off shaft at the front, fitted with a V-groove pulley, runs at half the engine speed.

During the design of the engine considerable attention was paid to the problem of accessibility to enable all the parts such as the fuel injectors, pumps, fuel and lubricating filters that are likely to require attention to be easily reached from above. The reason for this is that the water-cooled version was intended for, among others, marine application and would therefore in all probability be immediately below deck when installed in small vessels.

The bore of the larger engine is 3·74 in. and of the smaller 3·55 in., while a common stroke of 4 in. has been adopted for both units. A variable-speed governor controls the running of the engine at 1,250, 1,500 or 2,000 r.p.m. The brake horse-power corresponding to these speeds are 15·3, 18·5 and 24·6 in the larger engine, and 13·5, 16·5 and 19·6 in the smaller model. The average torque for each size is 64·5 lb.-ft. and 57 lb.-ft., respectively, and the maximum ratings are based on a brake mean effective pressure of 110 to 112 lb. per square inch.

To assist starting Weaver patent cold-starting injectors are fitted together with the normal decompressor and a geared turning handle. Provision is also made for a starter motor and in this case a dynamo and regulator are usually fitted. The rotation of the engine is clockwise.

The valves, which are made from EN52 steel, are fitted in the cylinder heads and are push-rod operated. C.A.V. injection pumps and pintle nozzles are used and these are mounted at the upper side of the engine. The fuel consumption obtained from test running is about 0·39 pint per brake horse-power per hour.

The oil-pressure release valve fitted has a simple external adjustment and can be serviced without dismantling any parts other than the release unit itself.

The air-cooled models are fitted with a cowling of the type illustrated and the flywheel is designed to serve also as an axial-flow fan to direct air to the cylinders. The water-cooled engines for marine application can be fitted with either an oil-operated gearbox or a gearbox using epicyclic gears and employing a hand selection lever. Both gearboxes can also have a reduction gear if necessary.

The low overall height, 20 in., makes the engine particularly suitable for installing in small vessels. The air-cooled and water-cooled models weigh 400 lb. and 480 lb., respectively. The water-cooled engine with a gearbox weighs between 600 and 650 lb., depending on the gearbox fitted.

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THE SHORT-HAUL VISCOUNT AIR-LINER

Further Details of the 800 *Series*

Since the announcement of the larger version of the Viscount air-liner, the 800 series, some 18 months ago, the specification has been modified, and details have been released recently by Vickers-Armstrongs Limited, Weybridge, Surrey.

The Viscount 800 series air-liner, particularly suited to high-density short-haul routes, is intended as a complementary machine to the medium-haul Viscount 700 series aircraft. It carries a maximum payload of 14,200 lb. over stage lengths up to 500 miles.

The Viscount 800 series will be 46 in. longer in the fuselage than the Viscount 700, and, in addition, the rear pressure bulkhead will be moved aft by 65 in., giving a total extra cabin length of 110 in. This will enable the aircraft to carry from 44 to 70 passengers compared with the 40 to 59 seats in the Viscount 700 series.

The wings will be almost exactly the same as on the latest Viscount 700D, and as in that aircraft the engines will be Rolls-Royce Dart RDA6 propeller turbines developing 1,697 effective horse-power.

Wide variations in the amount of freight capacity provided at the forward end of the aircraft are possible. To facilitate the loading of freight, the forward entrance door is rectangular and especially large, being 5 ft. high by 4 ft. wide.

The pantry and forward bulkhead will be mounted on rails so that the capacity of the compartment can be adjusted between freight and passengers. Where necessary, the passenger seats can be folded out of the way to make room for freight.

The seating arrangements can clearly be very flexible. Seventy passengers can be accommodated in twelve rows of five seats, two rows of four, and one row of two. In four-abreast, there can be fourteen rows plus two extra seats (58 total), or eleven rows of four (44 total).

The principal particulars of the 800 series aeroplane are as follow, the comparative figures for the Viscount 700D being given in brackets: span, 94 ft. (same); length, 85 ft. (81 ft. 2 in.); height, 26 ft. 9 in. (same); maximum take-off weight, 62,000 lb. (60,000 lb.); maximum landing weight, 57,000 lb. (54,000 lb.); weight empty, 37,800 lb. (35,100 lb.); maximum permanent fuel capacity, 1,950 Imperial gallons (same); fuel capacity with slipper tanks, 2,240 Imperial gallons (same); average cruising speed, 318 m.p.h. (321 m.p.h.); take-off distance with one engine out of action at maximum weight, 1,860 yards (1,730 yards); fuel consumption 309 Imperial gallons per hour (same).

The relationship between payload and range is shown in the graph reproduced below. In brief, the still-air range with maximum payload (14,200 lb.) is 1,060 statute miles (1,450 statute miles with 12,800 lb.). With the additional weight of slipper tanks, this is reduced to 1,035 miles. The maximum still-air range is 1,960 statute miles, with a payload of 7,500 lb. (2,190 statute miles with a payload of 8,200 lb.).

The version for British European Airways, the Viscount 802, in a 53-seat configuration (with three toilets) will have a maximum sector distance, with full load, of 950 miles. For shorter high-peak routes the accommodation can be for 70 passengers and baggage. In this layout two toilets are provided. The maximum payload in passengers and freight in the B.E.A. configuration is 13,350 lb., which can be carried for 650 statute miles with full reserves. One of B.E.A.'s normal layouts will be for 65 passengers in eleven rows of five seats, two rows of four, and one row of two.

The Viscount 802 will have the lowest direct operating cost per seat-mile of any aircraft in the British European Airways fleet. At 200-miles sector distance the direct operating costs are estimated at 2·2*d.*; at 300 miles, 1·8*d.*; at 400 miles, 1·5*d.*; decreasing to 1·25*d.* at 750 miles. For comparison, the B.E.A. direct operating costs per seat mile with DC3 aircraft are 2·9*d.* at 200 miles, 2·6*d.* at 300 miles, 2·45*d.* at 400 miles, and 2·15*d.* (optimum) at 650 miles. The Corporation's calculations show that the total operating cost of the Viscount 802 will vary between 4*d.* per seat-mile at 200 miles and 1·95*d.* per seat-mile at 750 miles. At 950 miles, the maximum sector distance which B.E.A. propose to operate with a 53-seat version, the direct operating cost is 1·26*d.* and the total cost 2*d.* per seat-mile.

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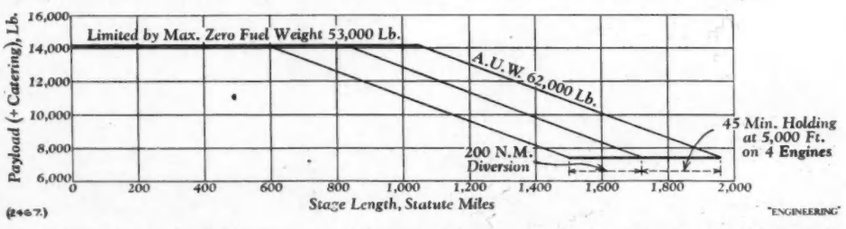
JET-PROPELLED TRAINING AIRCRAFT PROJECT

Boulton Paul Aircraft, Limited, Wolverhampton, have announced details of a project for a basic training aircraft, the P.124, powered by an Armstrong Siddeley Viper ASV5 turbo-jet engine.

Designed to introduce pupil pilots to jet flying at an early stage and to carry them forward to the advanced training stage, the good aerodynamic shape of the P.124 is expected to result in a performance substantially higher than that of current basic trainers, with an estimated maximum continuous cruising speed at 30,000 ft. of 320 m.p.h. and a top speed at the same altitude of 380 m.p.h. The all-up weight of the aircraft is 5,380 lb. and the useful load is 1,768 lb. It has a span of 32 ft., a length of 30 ft. 6 in., and a height of 9 ft. 9 in.

Side-by-side seating has been adopted, with a fully jettisonable cockpit hood. Despite the wide cockpit which this arrangement necessitates, an unusually good all-round view from either seat has been achieved. A retractable tricycle undercarriage with steerable nosewheel, capable of absorbing a vertical rate of descent of 14 ft. per second, is provided.

Operation of the undercarriage, flaps, dive brakes and wheel brakes is pneumatic, as in the Balliol, in which the pneumatic system has demonstrated a high standard of reliability.



Variation of payload with range for the Viscount air-liner. The total fuel usable is 1,950 Imperial gallons, and 400 lb. are allowed for take-off, circuits and landings.

THE COMET INVESTIGATIONS AT FARNBOROUGH

FATIGUE TESTS IN A WATER TANK

On the eve of the public inquiry on the Comet air-liner disasters, which opened in Westminster on Tuesday, October 19, the Royal Aircraft Establishment, Farnborough, disclosed some aspects of the investigations which they have been carrying out since Comet G-ALYP broke up and crashed in the sea near Elba in January. The results of these investigations have led to the positive conclusion that the crash was caused by a fatigue failure in the fuselage leading to a violent disintegration of the centre part of the pressure cabin. This explanation, it is thought, probably covers also the accident to Comet G-ALYY, which crashed in deep water near Naples on April 8.

Before the recovery of the wreckage, a series of technical investigations was initiated to examine every conceivable source of weakness, and these studies have continued in parallel with the examination of the wreckage. Three Comet I aircraft have been used—one for flight tests, one for pressure-fuelling tests and one for structural strength tests on a specially-designed ground rig.

LOADS AND VIBRATION IN FLIGHT

Some 70 test flights were carried out on a heavily-instrumented and extensively strain-gauged Comet. The cabin was not pressurised during these tests, the object of which was to check the design loading assumptions, to ascertain the structural stresses in steady flight and the response of the aircraft and pilot to manœuvres carried out in turbulent air conditions, to determine the vibration characteristics of the aircraft—whether the jet effluxes engendered high-frequency vibrations in the aircraft structure—and whether low-frequency effects arose from buffeting, mechanical excitation, landing loads, etc.

To determine whether mishandling or malfunctioning of the high-pressure refuelling system could lead to the possibility of explosion or of structural damage to the tank resulting from an excessive pressure build-up, a second Comet was subjected to rigorous refuelling tests. The strength of the wing was checked after a fuel tank had been deliberately broken.

REPEATED GUST AND PRESSURE LOADS

The third Comet, G-ALYU, was subjected to fatigue tests in a rig which, it is believed, is the first of its kind in the world, enabling the air loads on the wing and the pressure loads on the cabin to be applied and cycled simultaneously. The rig shown in the upper illustration, comprises a 200,000-gallon water tank 112 ft. long by 20 ft. wide by 16 ft. high, which accommodates the fuselage for pressure tests, the wings protruding through the tank through flexible seals on each side. The aircraft was wheeled into the rig when the latter was about half built. Working night and day, the rig was designed and constructed in about six weeks. The fuselage is appropriately ballasted to give the correct loading conditions. The whole of the tank and the interior of the fuselage are fitted with water to avoid the disruptive effects of a pressure-cabin failure in air.

TEST CYCLE

The test cycle comprised a continuous series of accelerated simulated 3-hour flights; applying to the wing by means of hydraulic rams the steady loads appropriate to the take-off, climb for ½ hour, 2 hours' cruising and ½-hour descent, and superimposing some 25 up and down 10-ft. per second "gusts." During the climb the cabin pressure was built up, by pumping in about 100 gallons of water, from zero to 8¼ lb. per square inch above atmospheric. This pressure was allowed to fall off slightly during the cruising period and was brought down to zero again on descent. The whole 3-hour "flight" lasted 5 minutes. To inspect the structure at intervals, it was necessary to drain the tank into a reserve tank.

In this rig, fatigue failures have been produced both in certain parts of the wing and in the fuselage. The fuselage failures are shown in the two lower illustrations in the right-hand column. (It will be understood that any aircraft structure can be thus broken if loaded for a sufficient number of cycles.) The aircraft has been repaired, and the tests are still continuing.

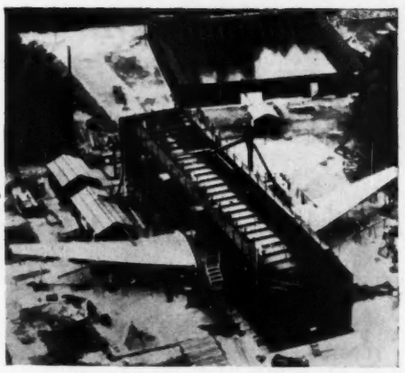
In addition to the ground and flight tests on full-scale aircraft, a series of dynamic model tests have been carried out to determine the motion of the aircraft after a major structural failure. Studied in conjunction with the investigation of the wreckage itself, these have assisted in establishing the sequence of the break-up.

WRECKAGE REBUILT

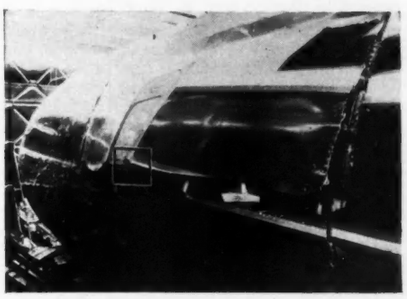
The vital part played by the Royal Navy's salvage operations in the solution of the Comet problem can probably only be appreciated fully by those who have had the opportunity to see the manner in which Farnborough have succeeded in identifying and building up the hundreds of pieces of wreckage on frameworks representing the fuselage, the wing, the tail unit and the engines so that it has been possible to trace the sequence of failure. Some 70 per cent. of the Comet wreckage is said to have been retrieved as indicated in the illustration below; the outer port wing is missing, and much of the fuselage. The manner in which a wreckage investigation is carried out is as follows. Normally, investigation commences at the site of the accident. In the case of the Comet which fell in the sea, the location from which the various pieces were retrieved afforded clues to the sequence in which the structure broke up. The building-up of identified pieces of wreckage into the major components shows up marked discontinuities.

The major separations are then examined to determine the type of failure and the direction. Impact marks and paint traces left by one component on another help in determining the sequence in which the parts failed and thus it is possible to locate the initial failure. The cause of the Comet failure was then interpreted in the light of the results of the tests that have already been outlined.

A report of the technical evidence in the Court of Inquiry appears elsewhere in this issue.



Rig for fatigue tests on the wings and pressure cabin.



General view of a fuselage fatigue failure which occurred during the rig tests.

Close-up of failed fuselage skin at bottom rear corner of escape hatch, in rig tests.

The amount of wreckage of the Comet G-ALYP recovered from the sea.

THE EUROPEAN MACHINE TOOL EXHIBITION AT MILAN

4—SOME UNITED STATES EXHIBITS

Continued from page 511

The "European" in the title of the Fourth European Machine Tool Exhibition was not intended to indicate that all of the machines exhibited were made in Europe; in fact, there were 32 United States firms (not 31, as previously stated) who occupied stands. The following were among the machines displayed.

The Gleason Works, 1,000 University-avenue, Rochester 3, N.Y., showed an extensive range of their gearcutting machines, including the No. 103 straight bevel Coniflex generator, designed primarily to complete straight bevel gears, with or without projecting front hubs, in one operation from the solid blank; the No. 104, which cuts straight bevel gears up to 8½-in. diameter and 3 D.P., which is claimed to be the fastest generator yet made for this type of work; the No. 105, a straight bevel grinder which, like the No. 103, was being exhibited for the first time; and the No. 106 hypoid generator, for cutting gears up to 8½-in. diameter and 4 D.P., or even finer.

GEAR-CUTTING MACHINES

The No. 103 machine, as stated, cuts straight bevel gears with or without front hubs. It will also cut what the Gleason Works term "Coniflex" gears, i.e., straight bevel gears with localised tooth contact, the ends of the teeth being slightly eased off to facilitate engagement and to avoid any concentration of the load at the end of a tooth under operating conditions. Two reciprocating "Coniflex" tools are used, and the tooth profile is produced by a relative rolling motion between the gear blank and the tools; the effect is as if the gear being cut were rolling with a mating crown gear, of which the tools represent a tooth. Once the gear blank is in the chuck, the operation of the machine is entirely automatic until the gear is finished, when the machine stops. The cradle carrying the tools is oscillated by cams and the work spindle revolves continuously, two features which permit faster operating cycles than were previously possible; and the movement of the slide and the chucking of the work are controlled by a single lever, providing a further saving of time in changing the work. For quantity production, the machine can be fitted with an automatic loader, with magazine feed.

The No. 105 "Coniflex" grinder is a completely automatic wet-type machine which will accommodate gears up to 8½ in. in diameter and 1⅜-in. face width, and from 3 to 24 diametral pitch. Gears coarser than about 20 D.P. are ground after cutting and hardening, but gears of finer pitch are ground directly from the solid blank. Two disc-type grinding wheels are used, grinding on the flat sides, and are automatically dressed as they operate, at pre-selected intervals. Movement of a hand lever starts the machine, which stops automatically when the gear is finished. A wheel-speed control unit increases the revolutions of the grinding-wheel spindles as the wheel diameter decreases, so that the grinding surface speed is maintained constant.

The National Acme Company, 170 East 131st-street, Cleveland 8, Ohio, showed in operation a new Acme-Gridley (Model RPA) six-spindle automatic chucking machine of 8-in. chuck capacity; the component being produced, a fine-grain iron casting 1¾ in. in diameter and 5⅛ in. long, required 12 tooling operations, performed in a completely automatic cycle taking only 20 seconds. Carbide tools are employed throughout, even for the core drills and the recessing tool, and the machine maintains extremely close tolerances and a fine finish, with feeds of 0·014 in. on the end-working tool-slides for turning and drilling.

DOUBLE-SPINDLE GRINDER

The Gardner Machine Company, Beloit, Wisconsin, showed their Type 125 26-in. double-spindle grinder (Fig. 22), designed for grinding such components as races for ball and roller bearings. It is fitted with a feed-through attachment, actuated by power-driven rolls of hard rubber, which feeds the components between the grinding wheels in a continuous stream. The loading magazine is mounted at the rear of the machine, and the finished components are returned to the same side of the machine, so that the operator can check samples for accuracy without leaving his position. The feed rolls are carried on adjustable slides, to permit the handling of workpieces from ¾-in. to 6-in. outside diameter and up to 1½ in. wide. As an example of the kind of work undertaken on the machine, it was stated that an outer bearing race, 2·8346-in. outside diameter and 0·748 in. wide, was ground at the rate of 2,500 an hour, over an hour's continuous running, the amount of stock removed ranging from 0·006 in. to 0·008 in. maximum overall, and the tolerances being 0·0002 in. for flatness and parallelism.

TURNING AND MILLING

With the exception of one lathe, all the machines on the stand of the Sundstrand Machine Tool Company, 2331 Eleventh-street, Rockford, Illinois, were made by their associates in Europe. They included a new type of single-end milling and centring machine, the No. 0 CentrMIL, designed to undertake miscellaneous shafting work on stock from ¾ in. to 3½ in. in diameter and from 5 in. to 48 in. in length. The cutter has an effective working diameter of 4 in. and makes 76 revolutions per minute. The feed rate can be varied between 1 in. and 18 in. per minute. The machine will take a centre drill up to ¾-in. maximum diameter, which can be given a stroke up to 2 in.; the drill feed is manually operated.

The 4A and 12A lathes are broadly similar in general arrangement, and together cover a wide range of work. The 12A is shown in Fig. 23. Both have front and rear tool carriages on which a variety of tools can be mounted for successive operation. Two ranges of spindle speeds are available: on the 4A machine, from 60 to 1,800 r.p.m. and from 120 to 3,600 r.p.m., and on the 12A, from 30 to 900 r.p.m. and from 40 to 1,200 r.p.m. The wide ratio between high and low speeds is obtained by having a choice of two driver-gear positions in the gear compartment, a feature which also makes it possible to get four speed changes with one set of two "pick-off" change gears. The 4A machine is made in three sizes, taking 15 in., 24 in. and 36 in., respectively, between the centres, with a minimum of ⅝ in. in each case; and the 12A machine is available in four sizes, taking 24 in., 36 in., 48 in. or 60 in. between centres, with a minimum of 1½ in. The 4A type has a maximum swing (radius) of 4⅜ in. over the slide and carriage, or 7½ in. over the rear ways; and the 12A, 7⅝ in. over the front cross-slide or 8 in. over the rear cross-slide, with a maximum of 12-in. radius over the rear carriage way or 19-in. diameter for chuck clearance, when a chuck is used.

The Sundstrand No. 33 Rigidmil, a standard model of milling machine, was also exhibited. This machine, which is provided with a mechanical feed, can be supplied at option with feed

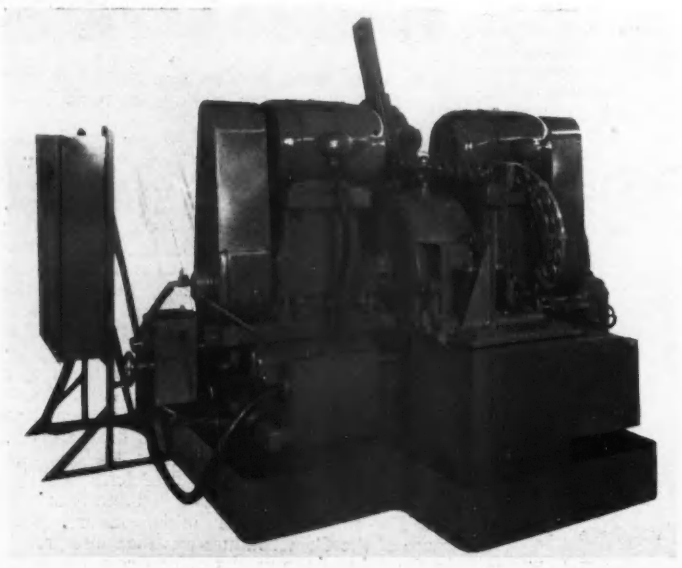


Fig. 22 Double-spindle grinding machine for grinding such components as races for ball and roller bearings. It incorporates a feed-through attachment which directs the components between the grinding wheels continuously.

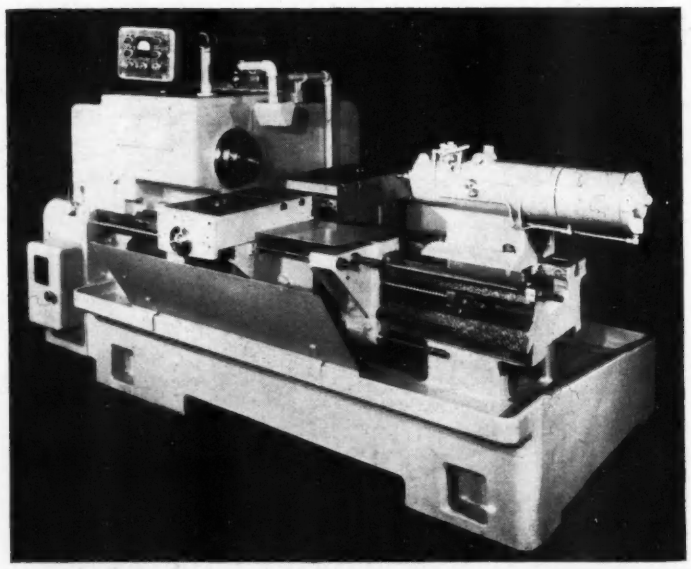


Fig. 23 Two driver-gear positions in the gear compartment of this lathe give it a high ratio between upper and lower speeds and make possible four changes with one set of two "pick-off" gears.

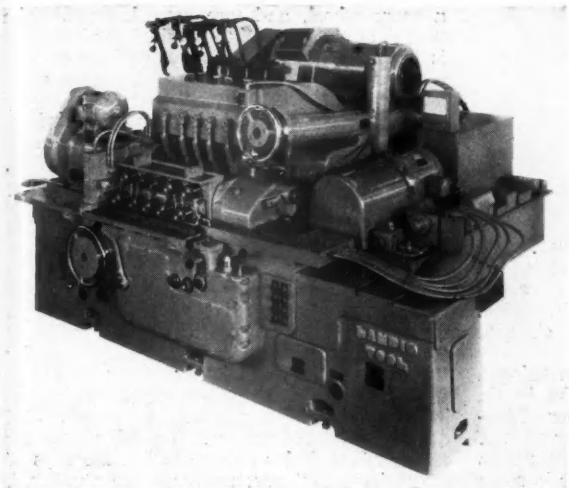


Fig. 24 The hydraulic grinding machine shown here is fitted with multiple wheels which enable it to grind a number of different diameters simultaneously.

Fig. 25 Vertical position.

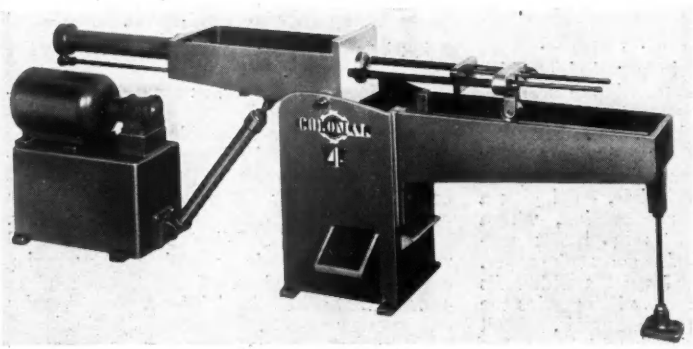


Fig. 26 Horizontal position.

Figs. 25 and 26 illustrate the vertical and horizontal positions of a broaching machine which can be changed from one working position to the other by means of a hydraulic lift cylinder.

rates of ½ in. to 50 in. or 1 in. to 100 in. per minute, and has a rapid traverse of 300 in. per minute, and is available with six types of head, giving a range of spindle motor speeds from 13 r.p.m. to 3,600 r.p.m.

The Landis Tool Company, Waynesboro, Pennsylvania, showed a selection of their precision grinding machines, of types particularly suitable for finishing crankshafts, crankpins, valves, and other components of internal combustion engines. The Type DH crankpin-grinding machine exhibited was an improved version of their earlier model and was shown in operation on crankshafts for four-cylinder engines. It removed from 0·030 in. to 0·040 in. from the four crank pins and the adjacent radii, and 0·010 in. from the sides of the webs, at a rate of 80 complete shafts per eight-hour working day. The machine is available with swings of 16 in. to 25 in. and in lengths to accommodate 32 in., 42 in. or 72 in. shafts, with four, six or eight cranks. An overhead type of wheel dresser, hydraulically operated, enables the wheels to be dressed without changing the set-up of the work. A new feature is the provision of a sensitive hand feed to the carriage, for positioning the crankshaft laterally as the wheel moves towards the work. A variable-speed motor is fitted so that the grinding-surface speed can be adjusted to the wheel diameter.

CENTRELESS GRINDER

The Landis 12 centreless grinder is another machine which was exhibited in an improved form, the principal changes being the provision for fitting automatic cycle controls and loaders. Work up to 3½ in. in diameter can be ground on this machine, using the standard work rests; with heavy-duty rests, work up to 4¾ in. in diameter can be handled. The grinding wheels are 20 in. in diameter and may be up to 10 in. wide, with regulating wheels, of the same width, up to 12 in. in diameter. Pressure lubrication is now fitted for the spindle bearings of the grinding-wheel head, with a safety device to ensure that the motor stops if the pressure fails. The machine can be fitted if desired with a hydraulic rapid in-feed and a slow grinding feed; and with a hand-operated dresser for the regulating wheel; and the new model has a speed-regulating wheel, which varies the revolutions by rheostatic control.

Other Landis machines exhibited included the Type H semi-automatic valve-seat grinder, fitted with a headstock which can be swivelled to grind valve-face angles from 0 deg. to 62½ deg., which will remove 0·010 in. of stock from the valve face at a rate of 400 pieces an hour; and the Type H-IW hydraulic grinder (Fig. 24), with multiple wheels, on which a number of diameters can be ground simultaneously. The H-IW machine displayed at Milan was tooled to remove from 0·007 in. to 0·010 in. of stock from three diameters at the one operation, the tolerances being held within 0·0005 in.; the production rate was 75 shafts an hour. The maximum swing of the work is 10 in. and the maximum outside dimension across the grinding wheels is 30 in. The standard wheel diameter is 36 in. and the wheels can be used down to a worn diameter of 26 in. Wheel dressing is by means of table-type diamond dressers in which the diamond bar is constrained to follow profile bars, mounted on the front of the bed, to dress the wheels to different shapes or diameters.

VERTICAL AND HORIZONTAL BROACHING

A new type of broaching machine, exhibited at Milan for the first time, was shown by the Colonial Broach Company, 21601 Hoover-road, Detroit, Michigan. It can be used either in a horizontal or a vertical position. In the latter position (Fig. 25), the rated capacity is eight tons for push and pull-down broaching and for press work; when used horizontally (Fig. 26), the machine has a rated capacity of six tons. The machine can be readily changed from one position to the other by means of a hydraulic lift cylinder, the bed section pivoting about the top of the base. Power for the lift cylinder is supplied by a hydraulic pump and motor, mounted on a separate base which also serves as a tank for the hydraulic fluid. The same power unit can also be employed as an auxiliary power take-off for other uses.

The American machines described above are mainly of the lighter high-speed types, but the heavier kinds were also represented. The Giddings and Lewis Machine Tool Company, of Fond du Lac, Wisconsin, exhibited a number of horizontal boring, drilling and milling machines and also a planer with a table 22 ft. long, a width between the double columns of 49½ in., a working height of 43 in., and a maximum speed of 400 ft. per minute. The 50 Series FUAR boring and drilling machine has a 7-in. main spindle with 60 in. of longitudinal travel, a 2½-in. auxiliary spindle with a longitudinal travel of 15 in., and is equipped with a two-ton crane for handling the work and the various attachments. The main spindle has 21 feeds and the auxiliary spindle 18 feeds. A somewhat smaller machine, the Series 30 (Fig. 27), has a built-in rotary table with a power drive, to rotate heavy or unwieldy work. The spindle, 5 in. in diameter, has 36 in. of longitudinal travel. The 36 standard spindle speeds range in progression from 7·5 to 467 r.p.m. and the nine high-speed rates are from 382 to 975 r.p.m. The machine is fitted with an extended saddle and auxiliary runways, and is driven by a 25-h.p. motor.

To be continued

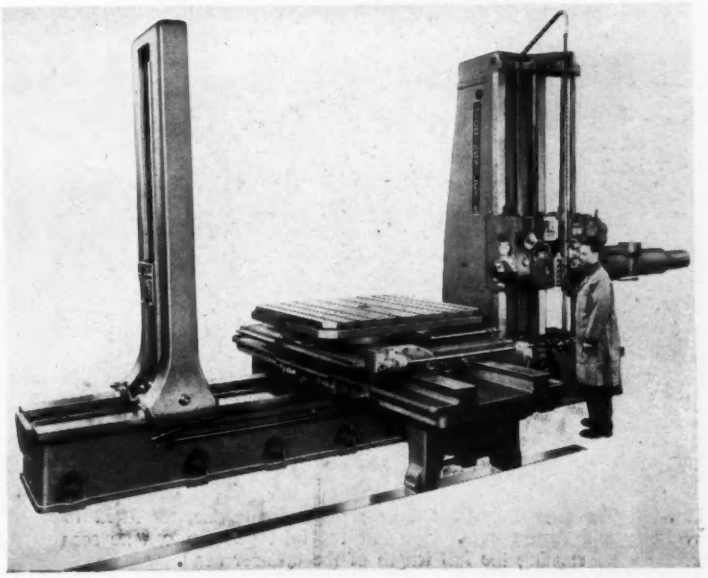


Fig. 27 Boring and drilling machine incorporating a built-in rotary table for handling heavy or unwieldy work. The spindle is 5 in. in diameter and has a travel of 36 in.

The Motor Show, London (October 20 to 30) *(continued from page 542)*

TRENDS IN THE DESIGN OF MOTOR CARS

2—SUSPENSION SYSTEMS AND ENGINES

Front-suspension design is now much more stabilised than that of rear suspension. The use of coil springs with double wishbones may now be regarded as orthodox practice, with a strong body of dissenters in Europe using torsion bars or transverse leaf springs. In the United States, much publicity has been given to the use of ball joints in the steering swivels on Ford, Mercury, and Lincoln. This enables one joint to accommodate both the steering movement and vertical-suspension deflection, and has long been a feature of such European cars as Citroen and Jaguar.

The Aston Martin DB 3S sports racing car, now sold to the public for the first time, departs from the established practice of the David Brown group in using torsion bars, with double trailing arms. This car was designed during the time when Professor Eberan von Eberhorst was the company's chief engineer, and he had of course great experience with similar layouts on Auto Union racing cars before the war.

Another suspension which comes in a distinct separate category is the Macpherson type, originated by a Ford engineer in Detroit, first used on the Dagenham Fords and now adopted for the Vedette to be built in France. It is probably the simplest arrangement in large production. It has a relatively high roll centre, the loads on the structure are well dispersed, and it confers very good stability on corners.

Where an anti-roll bar is used, it is customary to fit it at the front. Extra roll stiffness here increases the amount of weight transferred to the outer front tyre during cornering, thus increasing the tyre's slip angle, and producing the commonly sought under-steer characteristic. If the anti-roll bar is fitted at the rear, it tends to promote an outward drift in the outer rear tyre, causing over-steer. The Hillman Minx had the bar at the rear up to now, and had a slight over-steer characteristic, but with the fitting of a larger engine, with overhead valves giving a 16 per cent. increase in power, the bar has been moved to the front. The car now under-steers slightly, and stability on corners is much improved. The alteration has involved royalty payments to the United States, but this is probably less costly than trying to develop an adequate alternative. The bar used is of the simplest type, clamped directly to the wishbones.

It is thus interesting to find Austin using a rear-mounted stabiliser bar on both the Austin Cambridge and the new six-cylinder Westminster. It is clamped to the operating arms of the piston-type dampers. The Cambridge does exhibit a slight over-steer characteristic in some conditions, and this seems to have been sought deliberately as a way of obtaining the sensation of light steering which is thought desirable in these days when there is so much propaganda in favour of power-assisted steering in the United States.

END OF THE SPARE WHEEL?

One minor revolution in car design which comes rapidly nearer is the abolition of the spare wheel. Tubeless tyres are now produced by four tyre manufacturers in Britain. They are available on two makes of car and will probably be offered on most new cars during next year. They are all similar in principle, employing a carcase of conventional construction, with a lining variously described as butyl and non-porous rubber, over the inside and at the edges. A tyre will run for several months with nails through the cover, as the inner lining grips the foreign object and forms a seal around it. Small holes are sealed as the object is withdrawn, but larger holes may be patched, although Goodyear recommend the use of a special rubber plug inserted with a hollow needle. Frequent inflation checks are no longer required and air retention in normal service is such that longer life is obtained through running a greater proportion of the mileage at the recommended pressures. Volvo in Sweden are already selling a sports car without a spare wheel, and tyre manufacturers claim that the only precaution required for long trips is to carry a tube, which can be inserted in a tubeless tyre if the cover is badly damaged by accident. At present, tubeless tyres are only available in sizes up to 16 in. Such wheels have a 5-deg. taper on the seat which helps to improve sealing at the edges, whereas wheels of 17 in. and over have parallel rims, but this difficulty should be overcome before long. Prices and weights are generally the same as for a standard tyre with tube.

ENGINE DEVELOPMENT

Engine development is now showing the benefit from the availability of high-grade fuels and compression ratios are rising, although popular European engines still lag behind those in the United States. Development work carried out in connection with competition cars has led directly to improvements in breathing by better design of manifolds and ports and the days of the "siamesed" port appear to be numbered, because of the undesirable overlap in induction periods which it produces.

Engine sizes are also increasing. There has been an all-round increase in the United States since automatic transmissions were adopted and the trend seems to be developing in Europe. The new overhead-valve engine for the Hillman Minx is of 1,390 c.c., successor to a side-valve unit of 1,265 c.c. The Rover "75" goes up from 2 litres to 2,230 c.c. as a result of a manufacturing change which enables this engine to be made with the same block as the larger 2·6-litre "90," and in France the Vedette side-valve V8 engine made at the Ford works has been increased for the new model as far as possible within the framework of existing tooling.

Bentley have also followed the path of all who adopt automatic transmissions by boring out the cylinder block of the Continental to 4,875 c.c., although the 4,566-c.c. block remains on the other models, and the smaller size is still used by Rolls Royce. Apart from the transmission aspect, there may be a prestige point involved, as the Continental has only been able to reach 120 m.p.h. under favourable conditions, and it might be thought desirable to make this figure certain of accomplishment at a time when other high-speed closed cars are being sold with claimed maximum speeds of up to 160 m.p.h.

Bentley and Rolls Royce do not disclose

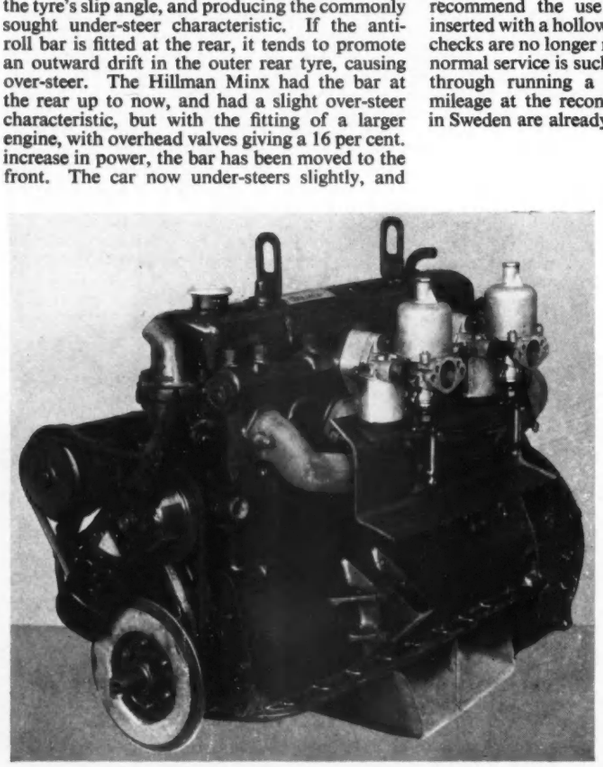


Fig. 13 The new B.M.C. C-type six-cylinder engine, as fitted to Wolseley and Austin cars. The integral inlet passage can be seen running the full length of the cylinder head.

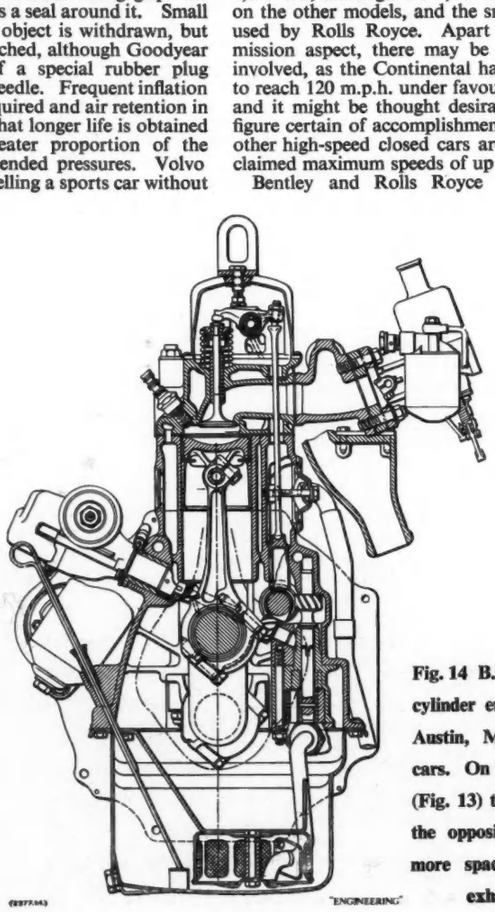


Fig. 14 B.M.C. B-type four-cylinder engine as fitted to Austin, Morris and M.G. cars. On the C-type engine (Fig. 13) the camshaft is on the opposite side to allow more space for inlet and exhaust ports.

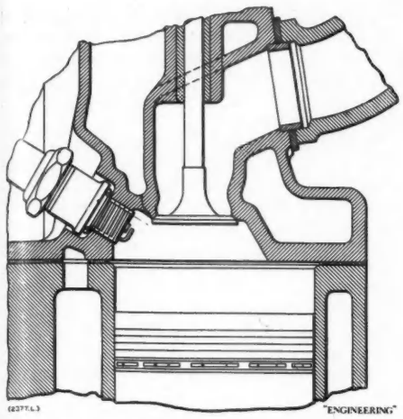


Fig. 15 Usual design of touring-car combustion chamber as exemplified by the Vauxhall Velox engine.

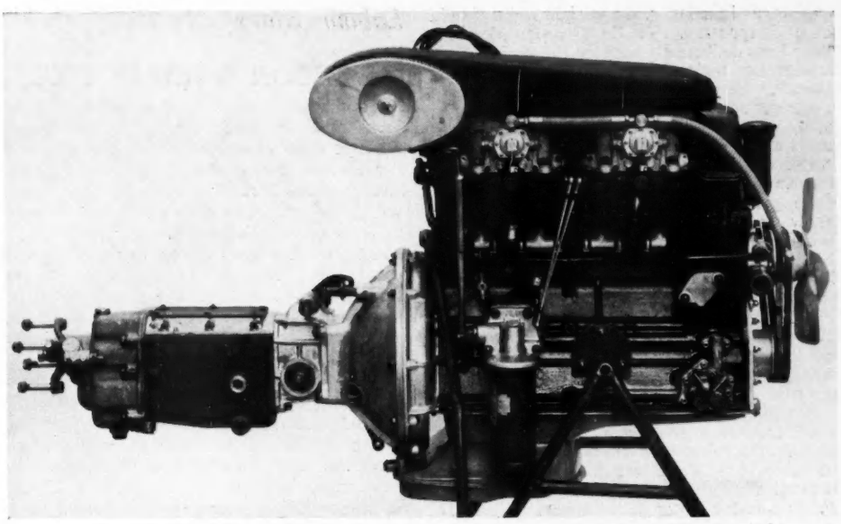


Fig. 16 A typical Continental sports-car engine—the Alfa-Romeo 1900 Super Sprint—with twin-choke carburettors such as are now coming into use in Britain.

information on their horse-power or torque figures, an attitude which may now be viewed with more sympathy when one sees the expedients to which American manufacturers are being driven by a false emphasis on totally-unusable horse-powers as a sales argument.

Development of cylinder head, manifold and exhaust-pipe design is giving increasing scope to the specialists armed with air-flow rigs and a wide experience spread over many different types of engine. Mr. H. Weslake, evolving a new cylinder head for the four-cylinder engine of the Austin Healey sports car, moved the inlet and exhaust ports from the left to the right side of the engine, in order to avoid the restrictions on port diameter imposed by the pushrods. Valve diameters were increased, and a modified heart-shaped combustion chamber was used, with the sparking plug set in the point. A two-pipe exhaust system is used, with the two middle cylinders exhausting into one pipe and the two end cylinders into another. The compression ratio has been raised from 7·5 to 8·3 : 1 and the power output has risen from 90 brake horse-power at 4,000 r.p.m. to 132 brake horse-power at 4,700 r.p.m.

The same basic principles are used for the new B.M.C. C-type six-cylinder engine on which Mr. Weslake collaborated (Fig. 13). The camshaft is on the right and the manifolds on the left. Cylinder head construction is quite unusual, as a long induction gallery is included in the casting, and feeds separate sloping inlet ports for each cylinder. There are also six separate exhaust ports, which should react favourably on exhaust-valve temperatures. As fitted to the Austin A90 the engine has a single down-draught Zenith carburettor, but on the Wolseley 6/90 it has two horizontal S.U. carburettors bolted to faces on the gallery. Combustion-chamber shape is as on the modified Austin Healey.

With a bore and stroke of 79·38 mm. by 88·9 mm. this new B.M.C. engine is more nearly "square" than the other in the series, but there seems to be no great belief in the principle of short strokes and big bores within the B.M.C. engine-design department. It will be interesting to follow the future development of these engines, for the tall block and long-throw crankshaft would not appear to offer the same rigidity when compression ratios are increased as those of the short-stroke engines. A cross-section of the B type is shown in Fig. 14.

The new Hillman Minx power unit is a square unit which has been designed to permit continuous development over a period of not less than eight years, and it is stated that all main components have been studied to permit eventual use with compression ratios as high as 12 to 1 if necessary. The bearing sizes are generous, the mains being 2·25 in. and big-ends 1·876 in. in diameter. The cylinder head has four separate inlet ports and separate exhaust ports. The combustion chambers are of an offset "bath-tub" shape, similar in general principle to those used on Standards and Vauxhalls (Fig. 15).

The Rootes group has been employing E.R.A., Limited, the racing-car manufacturers and experimental engineers, as consultants on cylinder-head and manifold design, and their special manifold arrangement is used on the Sunbeam Alpine sports model. The principle employed is to use an intermediate gas chamber inspired by the Helmholz resonator, with the column of gas in the inlet pipe as the mass, and the gas in the chamber as a spring medium. Naturally, true resonance is not employed, but as the inlet valve closes, the gas column is deflected back towards the gas chamber and is driven forward again in time for the next induction stroke. Optimum results are obviously achieved at one particular engine speed, but the benefit can be spread over a good range of revolutions, and patents have been taken out to cover a multiple-chamber system. On the Sunbeam Alpine the shape of the torque curve in the region 2,500 to 3,000 r.p.m. is greatly improved and a brake mean effective pressure of 155 lb. per square inch was obtained before making any alteration in port shape. Experiments with a similar system on another Rootes touring-car engine are said to have yielded 170 lb. per square inch b.m.e.p.

This growing interest in better breathing is reflected in the production of twin-choke carburettors, which British sports-car manufacturers have hitherto had to buy overseas. Solex, who also have a research arrangement with E.R.A., Limited, have evolved a series which is being used on Sunbeam Alpine and Aston Martin engines and on the Bristol sports racing team. Such carburettors are widely used in Italy, as on the Alfa-Romeo sports engines (Fig. 16).

With the announcement of the 1955 programmes due during the next few weeks, the American industry is expected to switch over entirely to short-stroke overhead-valve V8

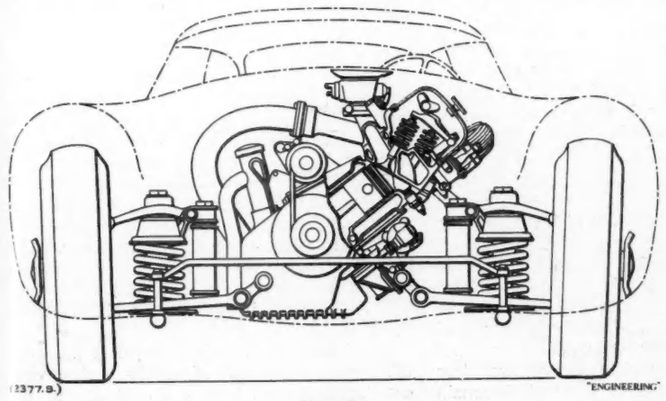


Fig. 17

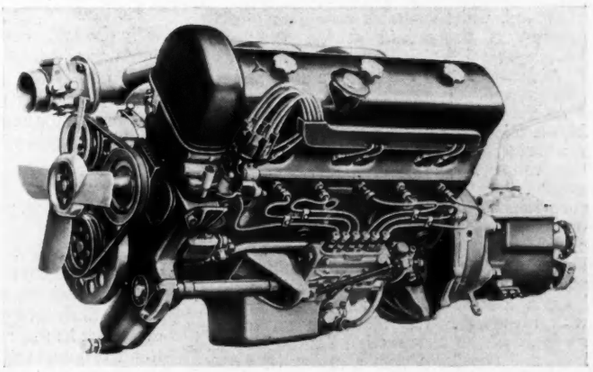


Fig. 18

Figs. 17 and 18 Bonnet height is reduced on the Mercedes Benz 300SL sports car by inclining the six-cylinder engine. Prototypes had carburettors as shown in the drawing, but production cars have fuel injection, as shown in Fig. 18.

engines, and the last of the straight eights should have disappeared. Yet in Europe, Mercedes Benz have deliberately adopted the straight-eight layout for their current Grand Prix racing models. Here the effect of engine length on passenger space is of no importance, and design analyses are said to have shown that the straight eight would always be ligher than the V8 as a racing car engine owing to the elimination of the extra overhead camshafts and their attendant drive gear. Naturally, these criteria do not apply to touring engines, as the American V8 uses only one camshaft. The problem of height on an in-line engine has been solved by laying the engine on its side in the Mercedes sports and racing cars. It will be noticed from Fig. 17 that the sports Mercedes engine employs in-line valves, with a combustion chamber using a " squish " area to promote turbulence, in the manner familiar on some British touring-car engines.

A detail point of interest in the latest American Ford engines is the elimination of the valve guide. The valve stems run directly in the metal of the cylinder head and this is said to have reduced valve operating temperatures by 100 deg. F. through the better heat transfer. When the bore becomes worn, it can be rebored to a larger size, and a valve with a thicker stem substituted.

To be continued

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NATIONAL FEDERATION OF ENGINEERS' TOOL MANUFACTURERS

Speaking at the annual dinner in London of the National Federation of Engineers' Tool Manufacturers on Wednesday, October 20, the Rt. Hon. Peter Thorneycroft, M.P., the President of the Board of Trade, said that it was the deliberate policy of Her Majesty's Government to get out of industry and to put the running of industry back into the company board rooms. In order to retain overseas business, however, it was essential that the Government should continue to subscribe to the General Agreement on Tariffs and Trade (GATT) unless undesirable trade barriers were to be built against the United Kingdom.

Mr. Thorneycroft was replying to the toast of " World Trade " which had been proposed by the Hon. R. A. Balfour, J.P., President of the Federation.

The toast of the Guests was proposed by the vice-president, Col. F. A. Neill, C.B.E., D.S.O.

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EXHIBITION AND FILM OF ZINC-ALLOY DIE CASTINGS

To coincide with the International Pressure Die Casting Conference, held at Church House, London, S.W.1, from October 25 to 28, the Zinc-Alloy Die Casters Association have arranged an exhibition in Birmingham. The exhibition, which contains several hundred die castings, is being held at the Birmingham Exchange Engineering Centre, Stephenson Place, Birmingham, 2, and will be open until Saturday, November 6.

At the opening of the exhibition on October 25, the colour film " Die casting, how else would you make it ? " was shown for the first time in this country. The film, which runs for 36 minutes, was made in America. It shows in considerable detail the production of die castings of many different sizes and varying degrees of complexity in zinc alloy, aluminium alloy and brass. Both the cold-chamber machine for high melting-point alloys and the machine with an integral melting pot for zinc alloys are dealt with at length. The film goes on to show methods of die construction for intricate castings, and concludes with a review of flashing, machining and various types of surface-finishing processes. It is being handled in Great Britain by the Zinc-Alloy Die Casters Association, Lincoln House, Turl-street, Oxford.

Labour Notes

LONDON DOCK STRIKE

Hopes that there might be an early break in the dock strike receded during the week-end, although there were signs at the time of going to press that more of the permanent men in the employ of the Port of London Authority on a weekly basis might be willing to return to work on Tuesday and Wednesday.

Many of these men belong to the Transport and General Workers' Union, which is not supporting the stoppage, and an official of the union stated last Saturday, after a mass meeting at St. Katharine Dock, that a " fair " majority of the men had voted to return.

About 4,000 dockers, including some from provincial ports, took part in a demonstration in London on Sunday and were addressed by leading officials of the National Amalgamated Stevedores and Dockers and the Watermen, Lightermen, Tugmen and Bargemen's Union, which are officially supporting the strike.

Figures issued last Saturday showed that there had been little alteration in the position during the latter part of last week. It was stated that there were about 44,000 men on strike and that 318 ships at London, Birkenhead, Hull, Liverpool, Rochester and Southampton were idle.

STOPPAGE OF OVERTIME IN THE MOTOR INDUSTRY

Among the other repercussions of the dock strike has been its serious effects in many directions on the country's export trade, and the motor industry has been among those to suffer. On October 20, Vauxhall Motors, Limited, announced that all overtime employment at their Luton factory was to be stopped, owing to the strike.

Production schedules for the following fortnight, it was stated, had been curtailed, and the factory had switched from export models to motor cars suitable for the home market.

In an official announcement to the 14,000 men and women in their employ, the firm stated that they could not continue to produce some three hundred vehicles a day and not be able to ship them. The firm had done everything they could to ensure that their workpeople were fully employed during the next two weeks. What might happen after that could not be foreseen at that stage.

The importance of the motor industry to Britain's export trade was stressed by Lord Nuffield just prior to the opening of the Motor Show, which he described as a " major feature " in the attainment of a favourable national balance sheet.

He said that the motor industry was undoubtedly one of Britain's greatest sources of overseas currency and its most prolific earner of dollars. The industry was still increasing its productivity and, by early next year, it was expected that the British Motor Corporation alone would be producing some 10,000 motor cars a week.

MINISTER'S PLEA TO DOCKERS

An appeal was made by Sir Walter Monckton in a statement in the House of Commons on October 19, that nothing should be done to prejudice the court of inquiry which he had set up to investigate the causes and circumstances of the dock overtime strike. Sir Walter said that when he met representatives of the two sides to the dispute in the preceding week, it was clear that the overtime question was still the main point at issue.

Having then in mind that he might find it necessary to appoint a court of inquiry, he had emphasised to the National Amalgamated Stevedores and Dockers the gravity of the situation which the stoppage had caused and had asked them whether, in the event of a court being set up, they would call off the strike.

He had pointed out that that could be done whether or not the overtime ban was maintained, and he felt that the suggestion could have been accepted by the union in the national interest, without in any way prejudicing its case.

Since then, Sir Walter said, a court of inquiry had been established, but he still hoped that the union would call off the strike, in the knowledge that such action could be taken without in the least damaging the case which the union desired to present.

The stoppage was having a serious effect on the export trade, it was endangering food supplies, and threatening to cause unemployment in other industries. If the stoppage continued, the effect would become progressively more serious.

SHIPBUILDING ORDERS CANCELLED

Side by side with the increased productivity of British shipyards during the year ended September 30 last, to which reference is made in a Weekly Survey note on another page, there has been a marked upward trend in the cancellation of orders for the larger-sized vessels.

During the three months July, August and September, orders previously placed for 15 vessels of a total of 121,000 gross tons were cancelled, while new orders for 55 smaller ships, received during the same period, together equalled only 50,000 gross tons.

In the first nine months of the present year as a whole, orders for new tonnage exceeded the tonnage cancelled, but only slightly. The figures were 188 ships of a total of 282,000 gross tons ordered and 29 ships of a total of 276,000 gross tons cancelled.

There are at present orders for some 4,500,000 gross tons of shipping on the books of British Shipbuilders, but the comparative figure for September 30, 1953, was 5,837,000 tons.

Improvements in the supplies of raw materials, the modernisation of many shipyards, and higher efficiency generally, have all helped to bring about the increased capacity of the industry.

DECLINE IN RETAIL PRICES

There was a fall of one point in the level of the index of retail prices during the monthly period ended September 14 last. According to an announcement of the Ministry of Labour and National Service on October 19, the index figure at mid-September stood at 143, compared with a figure of 144 for the period ended August 17, 1954. This was the second fall of one point in two months, as for the period ended July 13, 1954, the figure was 145, which represented the highest level reached by the index in its present form. Even so, the index is now three points higher than at the beginning of the present year, when a figure of only 140 was recorded.

The latest decline is ascribed by the Ministry as being due mainly to reductions in the average prices of certain foodstuffs, such as cooking apples, tomatoes, cabbages and butter. The reduction was partly offset by increases in the charges for cinema seats and in the prices of household coal in London and Southern England.

The interim index of retail prices measures the trend of the cost of articles and services entering into middle-class households in the United Kingdom. It was commenced on June 17, 1947, at which date the level of prices for all commodities was taken as 100.

FORTHCOMING EXHIBITIONS AND CONFERENCES

This list appears in the last issue of each month. An asterisk(*) indicates events appearing in the list for the first time. Particulars of forthcoming exhibitions and conferences not included below may have appeared in ENGINEERING, *September 24, page 414. Organisers are invited to send to the Editor particulars of forthcoming events as soon as arrangements are made.*

*ZINC-ALLOY DIE CASTING EXHIBITION.—Mon., Oct. 25, to Sat., Nov. 6, at the Birmingham Exchange, Stephenson-place, Birmingham. Organised by the Zinc Alloy Die Casters' Association, Lincoln House, Turl-street, Oxford. (Extended date.)

BRITISH OCCUPATIONAL HYGIENE SOCIETY'S CONFERENCE.—Mon., Nov. 1. at London School of Hygiene and Tropical Medicine, Keppel-street, W.C.1. Apply to Dr. C. N. Davies.

BOTTLING EXHIBITION (NINTH INTERNATIONAL).—Wed., Nov. 3, to Thurs., Nov. 11, in Paris. *Agents:* General-Tours Agence Generale de Tourisme (U.K.), Ltd., 25 and 26 Park-lane, London, W.1. Tel. HYDe Park 6854.

INTERNATIONAL CLOTHING AND MATERIAL INDUSTRIES EQUIPMENT EXHIBITION.—Wed., Nov. 3, to Thurs., Nov. 11, in Paris. Apply to the exhibition offices, 40 Rue du Colisée, Paris, 8e.

DAIRY EQUIPMENT EXHIBITION (SECOND).—Wed., Nov. 3, to Thurs., Nov. 11, in Paris. Organised by the Salon de l'Equipement Laitier, 28 Rue Louis le Grand, Paris, 2e.

FOOD INDUSTRIES AND TRADES EQUIPMENT EXHIBITION.—Wed., Nov. 3, to Thurs., Nov. 11, in Paris. Organised by the Salon de l'Equipement des Industries et des Commerces de l'Alimentation, 42 Rue du Louvre, Paris, ler. *Agents:* General-Tours Agence Generale de Tourisme (U.K.), Ltd., 25 and 26 Park-lane, London, W.1. Tel. HYDe Park 6854.

MECHANICAL HANDLING EXHIBITION.—Wed., Nov. 3, to Thurs., Nov. 11, in Paris. Organised by the Salon de la Manutention, 40 Rue du Colisée, Paris, 8e.

SAFETY IN CHEMICAL WORKS.—Fri., Nov. 5, to Sun., Nov. 7, at Harrogate. Conference organised by the Association of British Chemical Manufacturers, 86 Strand, London, W.C.2. Tel. COVent Garden 2363.

INDUSTRIAL TOOL AND EQUIPMENT SHOW.—Mon., Nov. 8, to Fri., Nov. 12, at the Show Mart Building, Montreal. Held in conjunction with the Montreal Materials Handling Show. *Agents:* John E. Buck & Co., 47 Brewer-street, London, W.1.

CYCLE AND MOTOR CYCLE SHOW.—Sat., Nov. 13, to Sat., Nov. 20, at Earl's Court, London, S.W.5. Organised by the British Cycle and Motor Cycle Manufacturers' and Traders' Union, Ltd., Warwick-road, Coventry. Tel. Coventry 62511.

PUBLIC WORKS AND MUNICIPAL SERVICES CONGRESS AND EXHIBITION.—Mon., Nov. 15, to Sat., Nov. 20, at Olympia, London, W.14. Organised by The Municipal Agency, Ltd., 70 Victoria-street, London, S.W.1. Tel. VICtoria 9132. See ENGINEERING, September 24, page 403.

"ELECTRONICS AT WORK."—Tues., Wed. and Thurs., Nov. 23, 24 and 25, at the Chamber of Commerce Hall, Birmingham. Organised by the Electrical and Electronics Group of the Scientific Instrument Manufacturers' Association of Great Britain, 20 Queen Anne-street, London, W.1. Tel. LANgham 4251.

X-RAY APPARATUS EXHIBITION.—Tues., Nov. 23, to Fri., Nov. 26, at the Royal Horticultural Hall, Vincent-square, London, S.W.1. Organised in conjunction with the congress of the British Institute of Radiology, 32 Welbeck-street, London, W.1. Apply to Mr. A. Beetlestone, Mullard, Ltd., New-road, Mitcham Junction, Surrey. Tel. Mitcham 2071.

INTERNATIONAL CYCLE AND MOTOR-CYCLE EXHIBITION (32ND).—Sat., Nov. 27, to Wed., Dec. 8, in the Mechanical Engineering Pavilion, Milan Fair site, Milan. Organised by the Italian Association of Manufacturers of Cycles, Motor Cycles and Accessories, 32 Via Mauro Macchi, Milan.

INTERNATIONAL "AUTOMATION" EXHIBITION.—Mon., Nov. 29, to Thurs., Dec. 2, at 242nd Coast Artillery Armory, 14th-street off Sixth-avenue, New York. Apply to Mr. Richard Rimbach, 845 Ridge-avenue, Pittsburgh 12, Pennsylvania, U.S.A.

POWDER METALLURGY SYMPOSIUM AND EXHIBITION.—Wed. and Thurs., Dec. 1 and 2, at Church House, Great Smith-street, London, S.W.1. Organised by the Iron and Steel Institute and the Institute of Metals. Apply to the secretary, Iron and Steel Institute, 4 Grosvenor-gardens, London, S.W.1. Tel. SLOane 0061. See ENGINEERING, April 23, page 518.

CHEMICAL AND PLASTICS EXHIBITION.—Fri., Dec. 3, to Sun., Dec. 12, at Porte de Versailles, Paris. Offices: 28 Rue Saint-Dominique, Paris, 7e. *Agents:* Butler's Advertising Service, 22 St. Giles High-street, London, W.C.2. Tel. TEMple Bar 5905.

SMITHFIELD SHOW AND AGRICULTURAL MACHINERY EXHIBITION.—Mon., Dec. 6, to Fri., Dec. 10, at Earl's Court, London, S.W.5. Inquiries to the exhibition manager, Smithfield Show, 148 Piccadilly, London, W.1. Tel. GROsvenor 4040.

*NATIONAL BOAT SHOW.—Thurs., Dec. 30, to Sat., Jan. 8, 1955, at Olympia, London, W.14. Inquiries to Mr. T. A. Webb, Ship and Boat Builders National Federation, 205 Regent-street, London, W.1. Tel. GROsvenor 5455.

PACKAGING EXHIBITION, FOURTH INTERNATIONAL.—Tues., Jan. 18, to Fri., Jan. 28, 1955, at Olympia, London, W.14. Organised by Provincial Exhibitions, Ltd., City Hall, Deansgate, Manchester. Tel. Deansgate 6363.

*STATIONERY TRADE FAIR.—Mon., Feb. 7, to Fri., Feb. 11, 1955, at Harrogate. Organised by the Stationers' Association of Great Britain and Ireland, 227 Strand, London, W.C.2. Tel. CENtral 7293.

BUSINESS EFFICIENCY EXHIBITION.—Tues., Feb. 8, to Fri., Feb. 11, 1955, at the Granby Halls, Leicester. Organised by the Office Appliance and Business Equipment Trades Association, 11-13 Dowgate-hill, London, E.C.4. Tel. CENtral 7771.

*AGRICULTURAL MACHINERY AND EQUIPMENT EXHIBITION (INTERNATIONAL).—Sun., Feb. 13, to Sun., Feb. 20, 1955, at Brussels. Organised by the Société de Mecanique et d'Industries Agricoles S.A., 29 Rue de Spa, Brussels.

*HARDWARE TRADES FAIR.—Mon., Feb. 14, to Fri., Feb. 18, 1955, at the Royal Horticultural Society's Halls, Vincent-square, London, S.W.1. Organised by Universal Exhibitions Ltd., 74 Holland Park, London, W.11. Tel. PARk 7360.

*SCOTTISH NATIONAL HANDICRAFTS AND HOMECRAFTS EXHIBITION.—Thurs., Feb. 24, to Sat., Mar. 5, 1955, at the McLellan Galleries, Sauchiehall-street, Glasgow. Organisers: Henderson Exhibitions Ltd., 74 Holland Park, London, W.11. Tel. PARk 7360.

*NICE INTERNATIONAL FAIR.—Sat., Feb. 26, to Mon., Mar. 14, 1955. Inquiries to the secretary, Foire de Nice, 5 Rue Hotel de Ville, Nice.

*LEIPZIG INTERNATIONAL SPRING FAIR.—Sun., Feb. 27, to Wed., Mar. 9, 1955. *Agents:* Willoughby and Young, 6a Smith-street, London, S.W.3. Tel. SLOane 1594.

*STATIONERY AND BOOK TRADES FAIR.—Mon., Feb. 28, to Fri., Mar. 4, 1955, at the Royal Horticultural Society's New Hall, Greycoat-street, London, S.W.1. Organised by National Newsagent Ltd., 149 Fleet-street, London, E.C.4. Tel. CITy 2604.

*AGRICULTURAL MACHINERY EXHIBITION (INTERNATIONAL).—Tues., Mar. 1, to Sun., Mar. 6, 1955. *Agent:* Mr. R. C. Liebman, 178 Fleet-street, London, E.C.4. Tel. CITy 5889.

*FRANKFURT INTERNATIONAL TRADE FAIR.—Sun., Mar. 6, to Thurs., Mar. 10, 1955. *Agents:* L.E.P. Transport, Ltd., Sunlight Wharf, Upper Thames-street, London, E.C.4. Tel. CENtral 5050.

*VIENNA INTERNATIONAL SPRING FAIR (36TH).—Sun., Mar. 13, to Sun., Mar. 20, 1955. *Agents:* The British Austrian Chamber of Commerce, 29 Dorset-square, London, N.W.1. Tel. PADdington 7476.

ASTE WESTERN INDUSTRIAL EXPOSITION.—Mon., Mar. 14, to Fri., Mar. 18, 1955, at Los Angeles, California. Organised by the American Society of Tool Engineers, 10700 Puritan-avenue, Detroit 38, Michigan, U.S.A.

(A.S.E.E.) ELECTRICAL ENGINEERS' EXHIBITION.—Tues., Mar. 15, to Sat., Mar. 19, 1955, at Earl's Court, London, S.W.5. Sponsored by the Association of Supervising Electrical Engineers, 54 Station-road, New Barnet, Hertfordshire. Apply to Mr. P. A. Thorogood, Electrical Engineers (A.S.E.E.) Exhibition, Ltd., 23 Bloomsbury-square, London, W.C.1. Tel. MUSeum 3450.

*UTRECHT INTERNATIONAL SPRING FAIR.—Tues., Mar. 22, to Thurs., Mar. 31, 1955. *Agent:* Mr. W. Friedoff, 10 Gloucester-place, London, W.1. Tel. WELbeck 9971.

*COPENHAGEN INTERNATIONAL FAIR (9TH).—Fri., Mar. 25, to Sun., April 3, 1955, Technical Section. Fri., April 15, to Sun., April 24, 1955, Commercial Section. Organised by Dansk Udstillings Syndikat A/S, Forums Anneks Julius, Thomsens Plads, Copenhagen K, Denmark.

FACTORY EQUIPMENT EXHIBITION (THIRD).—Mon., Mar. 28, to Sat., April 2, 1955, at Earl's Court, London, S.W.5. Apply to Mr. J. E. Holdsworth, 117 Kingsway, London, W.C.2. Tel. CHAncery 2318.

*SWISS INDUSTRIES FAIR.—Sat., April 16, to Tues., April 26, 1955, at Basle, Switzerland. Apply to the Swiss Legation, 18 Montague-place, Bryanston-square, London, W.1. Tel. PADdington 0701.

PHYSICAL SOCIETY'S EXHIBITION OF SCIENTIFIC INSTRUMENTS AND APPARATUS (39TH).—Mon., April 25, to Thurs., April 28, 1955, at the Royal Horticultural Hall, Vincent-square, London, S.W.1. Organised by the Physical Society, 1 Lowther-gardens, South Kensington, London, S.W.7. Tel. KENsington 0048.

BRITISH INDUSTRIES FAIR.—Mon., May 2, to Fri., May 13, 1955, at Olympia, London, W.14; and Castle Bromwich, Birmingham. Particulars from British Industries Fair Ltd., Ingersoll House, 9 Kingsway, London, W.C.2. Tel. COVent Garden 1461; or from the general manager, British Industries Fair, 95 New-street, Birmingham, 2. Tel. Midland 5021.

ACHEMA XI GERMAN CHEMICAL APPARATUS CONGRESS AND EXHIBITION.—Sat., May 14, to Sun., May 22, 1955, at Frankfurt-on-Main. Organised by Dechema Deutsche Gesellschaft für chemisches Apparatewesen, Rheingau-Allee 25, Frankfurt-on-Main.

NEW YORK TRADE FAIR.—Sun., May 15, to Thurs., May 19, 1955, at the Armory, 25th-street, Manhattan, New York. Organised by International Trade Shows, 545 Fifth-avenue, New York.

INTERNAL COMBUSTION ENGINE CONGRESS, INTERNATIONAL.—"COLLOQUY 1955—THE HAGUE."—Mon., May 23, to Sat., May 28, 1955, at Scheveningen, Holland. Organised by the Congrès International des Moteurs a Combustion Interne, 11 Avenue Hoche, Paris, 8e. Inquiries in Britain may be sent to the British Internal Combustion Engine Research Association, 111-112 Buckingham-avenue, Slough, Buckinghamshire. Tel. Slough 20295. See ENGINEERING, July 16, page 72.

CANADIAN INTERNATIONAL TRADE FAIR (EIGHTH).—Mon., May 30, to Fri., June 10, 1955, at Toronto. Further information from Miss M. A. Armstrong, Canadian Government Exhibition Commission, Canada House, Trafalgar-square, London, S.W.1. Tel. WHItehall 8701.

*BATH AND WEST AGRICULTURAL SHOW.—Wed., June 1, to Sat., June 4, 1955, at Launceston, Cornwall. Organised by the Bath and West and Southern Counties Society, 3 Pierrepont-street, Bath. Tel. Bath 3010.

BRITISH PLASTICS EXHIBITION.—Wed., June 1, to Sat., June 11, 1955, at Olympia, London, W.14. Organised by "British Plastics," Dorset House, Stamford-street, London, S.E.1. Tel. WATerloo 3333.

WORLD PETROLEUM CONGRESS.—Mon., June 6, to Wed., June 15, 1955, in Rome. Apply to the secretary, Institute of Petroleum, 26 Portland-place, London, W.1. Tel. LANgham 2250.

BUSINESS EFFICIENCY EXHIBITION.—Mon., June 6, to Thurs., June 16, 1955, at Olympia, London, W.14. Organised by the Office Appliance and Business Equipment Trades Association, 11-13 Dowgate-hill, London, E.C.4. Tel. CENtral 7771.

SAFETY AND FACTORY EFFICIENCY EXHIBITION.—Fri., June 24, to Fri., July 1, 1955, at Bingley Hall, Birmingham. Information from the Industrial Safety Training Centre, Museum of Science and Industry, Newhall-street, Birmingham, 3.

*GREAT YORKSHIRE AGRICULTURAL SHOW.—Tues., July 12, to Thurs., July 14, 1955, at Harrogate, Yorkshire. Organised by the Yorkshire Agricultural Society, Cliftonfield, Shipton-road, York. Tel. York 3102.

*INTERNATIONAL WATER SUPPLY EXHIBITION.—Mon., July 18, to Thurs., July 21, 1955, at the Royal Horticultural Society's New Hall, Greycoat-street, London, S.W.1. Inquiries to Mr. L. Millis, O.B.E., International Water Supply Association, 34 Park-street, London, W.1. Tel. GROsvenor 1092.

*BUILDING EXHIBITION (26TH).—Wed., Nov. 16, to Wed., Nov. 30, 1955, at Olympia, London, W.14. Organised by the Building Trades Exhibition, 4 Vernon-place, London, W.C.1. Tel. CHAncery 2223.

NOTICES OF MEETINGS

Association of Supervising Electrical Engineers

LONDON
Discussion on "Modern Magnets." South-East London Branch. Congregational Church, Court-road, Eltham, S.E.9. Tues., Nov. 2, 8 p.m.
"Cored Solders," by H. L. Schuster. North London Branch. 677 Green Lanes, Harringay, N.4. Wed., Nov. 3, 7.45 p.m.
"Push-Button and Loud-Speaker Intercommunication Telephones" by D. H. Weston. West London Branch, 134 Kingstreet, Hammersmith, W.6. Tues., Nov. 2, 7.30 p.m.
BOLTON
"Elements of Television," by A. Hollingsworth. Bolton Branch. Balmoral Hotel, Bradshawgate, Bolton. Mon., Nov. 1, 7.30 p.m.
CARDIFF
Film Evening. South Wales Branch. Angel Hotel, Westgate-street, Cardiff. Tues., Nov. 2, 7.30 p.m.
CROYDON
Various short papers. South London Branch. Café Royal, North End, Croydon. Thurs., Nov. 4, 8 p.m.
ILFORD
"Modern Lighting Technique," by R. Pye. North-East London Branch. Angel Hotel, Ilford. Mon., Nov. 1, 8 p.m.
LEEDS
"Stage Light Effects," by E. E. Farraday. Leeds Branch. Great Northern Hotel, Leeds. Mon., Nov. 1, 7.30 p.m.
LIVERPOOL
"Modern Lighting Technique," by R. Pye. Liverpool Branch. Liverpool Engineering Society, 9 The Temple, 24 Dale-street, Liverpool. Fri., Nov. 5, 7.30 p.m.

British Institution of Radio Engineers

GLASGOW
"Latest Developments in Television Cameras," by H. McGhee. Scottish Section. Institution of Engineers and Shipbuilders in Scotland, 39 Elmbank-crescent, Glasgow. Thurs., Nov. 4, 7 p.m.
LIVERPOOL
"Radio-Receiving Valve Manufacture," by G. P. Thwaites. Merseyside Section. College of Technology, Byron-street, Liverpool 3. Thurs., Nov. 4, 7 p.m.
MANCHESTER
"Electronic Servo Mechanisms," by J. L. Russell. North-Western Section. College of Technology, Sackville-street, Manchester. Thurs., Nov. 4, 7 p.m.

Chemical Society

LONDON
"Open and Closed Sequences in Reaction Kinetics," by Professor J. A. Christiansen. Imperial College of Science and Technology, South Kensington, S.W.7. Thurs., Nov. 4, 7.30 p.m.
BRISTOL
"Melting and Crystal Structure," by Professor A. R. Ubbelohde. Bristol Branch. The University, Bristol. Thurs., Nov. 4, 7 p.m.
CAMBRIDGE
"Some Mould Colouring Matters," by Professor A. Robertson. Cambridge Branch. Chemical Laboratory, The University, Cambridge. Fri., Nov. 5, 8.30 p.m.
LEEDS
"The Mechanism of Some Electron-Transfer Reactions," by Professor C. E. H. Bawn. Leeds Branch. The University, Leeds. Tues., Nov. 2, 6.30 p.m.

Incorporated Plant Engineers

LONDON
"Science of Applied Chromatics," by E. M. Barford. Royal Society of Arts, John Adam-street, Adelphi, W.C.2. Tues., Nov. 2, 7 p.m.
EDINBURGH
Open Meeting. Edinburgh Branch. 25 Charlotte-square, Edinburgh. Tues., Nov. 2, 7 p.m.
LEICESTER
"Process and Industrial Heating," by J. C. Edwards. Leicester Branch. Leicester College of Art and Technology, The Newarkes, Leicester. Wed., Nov. 3, 6.30 p.m.
PETERBOROUGH
"Metal Spraying," by W. E. Ballard. Peterborough Branch. Offices of the Eastern Gas Board, Church-street, Peterborough. Thurs., Nov. 4, 7.30 p.m.
SOUTHAMPTON
"Maintenance Costs," by H. E. Baker; and "Steam Costs," by E. C. Rogers. Southampton Branch. Polygon Hotel, Southampton. Wed., Nov. 3, 7.30 p.m.

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IMPROVING THE ROADS

Overcoming Financial Objections

At a recent Press conference Lord Derwent, chairman of the British Road Federation, launched two new publications, "Roads—How other countries are financing them," and "Roads—How other countries are building them."

In the course of the ensuing discussion it was acknowledged that the construction of new roads within the United Kingdom was in no way limited by the technical problems involved; labour, materials and the technical knowledge required to build the roads were all said to be available to meet the needs of a major construction programme. In the view of the Federation it was only the failure of the Government to authorise the necessary expenditure by one of the several possible methods that hindered the bringing into being of a road system required to meet present-day requirements. In answer to questions it was said by officials of the Federation that there was no problem involved in acquiring the necessary land and property to construct new roads or eliminate "bottlenecks."

Institute of British Foundrymen

BURNLEY
"An Approach to the Mechanised Production of Moulds," by J. Hill. Burnley Section. Municipal College, Ormerod-road, Burnley. Wed., Nov. 3, 7.30 p.m.
MANCHESTER
"Some Aspects of High-Duty Cast Iron" and "Is Green Sand Moulding Deteriorating?" by C. R. van der Ben and H. Haynes. Lancashire Branch. Engineers' Club, Albert-square, Manchester, 1. Wed., Nov. 3, 7 p.m.
SHEFFIELD
"Castings versus Fabrications," by H. Mottram. Sheffield Branch. College of Technology, Pond-street, Sheffield. Mon., Nov. 1, 7.15 p.m.

Institute of Fuel

GLASGOW
"The Constitution of Coal Tar," by Dr. D. McNeil. Scottish Section. Royal Technical College, Glasgow. Mon., Nov. 1, 7 p.m.
SWANSEA
"Back-Pressure Regeneration," by C. Ungoed. South Wales Section. The Y.M.C.A., Kingsway, Swansea. Fri., Nov. 5, 6 p.m.

Institute of Metals

LONDON
"Trends in Metallurgy," by Professor A. G. Quarrell. London Local Section. Royal School of Mines, South Kensington, S.W.7. Thurs., Nov. 4, 7 p.m.
OXFORD
"Ceramics," by Dr. J. White. Oxford Local Section. Cadena Café, Cornmarket-street, Oxford. Tues., Nov. 2, 7 p.m.

Institute of Road Transport Engineers

BEDFORD
"Clutch and Brake Linings," by L. P. Godfrey. Eastern Centre. Swan Hotel, Bedford. Wed., Nov. 3, 7 p.m.
EDINBURGH
"Hydraulic Transmissions," by J. Houghton. Scottish Centre. North British Station Hotel, Edinburgh. Mon., Nov. 1, 7.30 p.m.
PRESTON
"Commercial-Vehicle Electrical Equipment," by C. T. Corney and A. V. Waters. North-West Centre. Victoria Station Hotel, Preston. Tues., Nov. 2, 7.30 p.m.

Institute of Welding

LONDON
"Design Aspect of Tubular Construction," by R. G. Taylor. North-London Branch. 26 Portland-place, W.1. Thurs., Nov. 4, 7.30 p.m.

Institution of Civil Engineers

LONDON
Presidential Address by David M. Watson. Tues., Nov. 2, 5.30 p.m.

Institution of Electrical Engineers

LONDON
"Pumped Storage for Peak-Load Power Supplies," by C. D. Gardiner. London Students' Section. Mon., Nov. 1, 6.30 p.m.
Discussion on "Boreholes: Instrumentation for Measurements at Depth," opened by P. Threadgold. Measurements Section. Tues., Nov. 2, 5.30 p.m.
"A Transatlantic Telephone Cable," by Dr. M. J. Kelly, Sir Gordon Radley, G. W. Gilman and R. J. Halsey. Thurs., Nov. 4, 5.30 p.m.
BIRMINGHAM
"Possibilities of a Cross-Channel Power Link Between the British and French Supply Systems," by D. P. Sayers, M. E. Laborde and F. J. Lane. South Midland Centre. James Watt Memorial Institute, Great Charles-street, Birmingham. Mon., Nov. 1, 6 p.m.
CARDIFF
"Manchester-Kirk o'Shotts Television Radio-Relay Systems," by G. Dawson and others. Western Centre. South Wales Institute of Engineers, Park-place, Cardiff. Mon., Nov. 1, 6 p.m.
HOVE
"An Assessment of the Impregnated Pressure Cable," by Dr. L. G. Brazier, D. T. Hollingsworth and Dr. A. L. Williams. Southern Centre. Offices of the Southern Electricity Board, Hove. Wed., Nov. 3, 6.30 p.m.
LEEDS
"Technical Arrangements for the Sound and Television Broadcasts of the Coronation Ceremonies on June 2, 1953," by W. S. Proctor, M. J. L. Pulling and F. Williams. North Midland Centre. Offices of the Yorkshire Electricity Board, 1 Whitehall-road, Leeds. Tues., Nov. 2, 6.30 p.m.
LIVERPOOL
"Aluminium-Sheathed Cables," by P. M. Hollingsworth and P. A. Raine. Mersey and North Wales Centre. Liverpool Royal Institution, Colquitt-street, Liverpool. Mon., Nov. 1, 6.30 p.m.
MANCHESTER
"Aluminium-Sheathed Cables," by P. M. Hollingsworth and P. A. Raine. North-Western Centre. Engineers' Club, Albert-square, Manchester, 1. Tues., Nov. 2, 6.15 p.m.
WORKINGTON
"Safety in the Use of Portable and Transportable Electrical Equipment in Industry," by J. Bunting. Cumberland Technical College, Workington. Fri., Nov. 5, 7 p.m.

Institution of Engineering Designers

NEWCASTLE-UPON-TYNE
"Research and the Designer," by A. F. B. Young. North-East Branch. 6 Higham-place, Newcastle-upon-Tyne. Mon., Nov. 1, 7.15 p.m.

Institution of Engineering Inspection

BIRMINGHAM
"The Reclamation of Porous Castings by Impregnation" by P. J. Young. Birmingham Branch. Birmingham Chamber of Commerce, 95 New-street, Birmingham. Wed., Nov. 3, 7.30 p.m.
COVENTRY
"Application of Gas Turbines to Road Transport," by P. A. Phillips. Coventry Branch. Coventry Technical College, Coventry. Tues., Nov. 2, 7.30 p.m.

Institution of Mechanical Engineers

LONDON
Discussion on "The Place of the Gas Turbine cum Two-Stroke Engine/Gas-Generator Unit in the Future Pattern of the Oil-Engine Industry." Internal-Combustion Engine Group. Tues., Nov. 2, 6.45 p.m.
"An Experimental Coal-Burning Gas Turbine," by Professor L. D. Mordell. Internal-Combustion Engine Group. Fri., Nov. 5, 5.30 p.m.
NEWCASTLE-UPON-TYNE
Parsons Memorial Lecture on "Factors Influencing the Continuing Development of the Steam Turbine," by F. Dollin. North-Eastern Branch. King's College, Newcastle-upon-Tyne. Mon., Nov. 1, 6 p.m.

Institution of Production Engineers

GLASGOW
Open Discussion. Glasgow Section. Institution of Engineers and Shipbuilders in Scotland, 39 Elmbank-crescent, Glasgow, C.2. Thurs., Nov. 4, 7.30 p.m.
GLOUCESTER
"Productivity," by F. L. Daniels. Gloucester Section. Bell Hotel, Gloucester. Thurs., Nov. 4, 7.15 p.m.
HALIFAX
"The Shell Moulding Process," by D. N. Buttrey. Halifax Section. White Swan Hotel, Halifax. Tues., Nov. 2, 7.15 p.m.
NOTTINGHAM
"Costing and Measurement of Productivity," by W. Coutts Donald. Nottingham Section. Welbeck Hotel, Milton-street, Nottingham. Tues., Nov. 2, 7 p.m.
PETERBOROUGH
"Motion and Time Study," by Miss Anne G. Shaw. Peterborough Section. Campbell Hotel, Bridge-street, Peterborough. Wed., Nov. 3, 7.30 p.m.
STAINES
"Recent Developments in Work Study," by N. A. Dudley. Reading Section. Petters Ltd., Causeway Works, Staines, Middlesex. Thurs., Nov. 4, 7.30 p.m.

Institution of the Rubber Industry

LIVERPOOL
"Latex Foam Rubber," by G. J. Bibby. Merseyside Section. 24 Hatton-garden, Liverpool. Mon., Nov. 1, 7 p.m.
NEWCASTLE-UPON-TYNE
Various short papers. North-East Section. Neville Hall, Newcastle-upon-Tyne. Mon., Nov. 1, 7 p.m.

Institution of Structural Engineers

COLWYN BAY
"Llandarcy Refining Expansion Engineering," by F. V. M. Bell. Wales and Monmouthshire Branch. County Buildings, Colwyn Bay. Sat., Nov. 6, 6 p.m.
MIDDLESBROUGH
"Further Studies of Load Distribution in Bridge Decks," by Mr. G. Little. Northern Counties Branch. Cleveland Scientific and Technical Institution, Middlesbrough. Tues., Nov. 2, 6.30 p.m.
STAFFORD
"Examples of Site Exploration," by Edgar Morton. Midland Counties Branch. Public Library, Stafford. Thurs., Nov. 4, 7 p.m.
SWANSEA
"Llandarcy Refining Expansion Engineering," by F. V. M. Bell. Wales and Monmouthshire Branch. Mackworth Hotel, Swansea. Tues., Nov. 2, 6.30 p.m.

Junior Institution of Engineers

LONDON
Film Evening. Fri., Nov. 5, 7 p.m.
BIRMINGHAM
"Modern Tendency of Railway-Signalling Practice," by W. J. Sadler. Midland Section. James Watt Memorial Institute, Great Charles-street, Birmingham. Wed., Nov. 3, 7 p.m.

Royal Aeronautical Society

LONDON
"Design of Small Jet Engines," by H. S. Rainbow. Tues., Nov. 2, 7 p.m.
HULL
First Sir George Cayley Lecture, by Capt. J. L. Pritchard. Royal Station Hotel, Hull. Thurs., Nov. 4, 7 p.m.

Royal Society of Arts

LONDON
"Looking Ahead." Chairman's Inaugural Address. Wed., Nov. 3, 2.30 p.m.

Sheffield Metallurgical Association

SHEFFIELD
"Some Theoretical Aspects of Practical Rod Rolling," by E. W. Gregory. B.I.S.R.A. Laboratories, Hoyle-street, Sheffield, 3. Tues., Nov. 2, 7 p.m.

The address and telephone number of the headquarters of each institution are given below. Meetings in the headquarters town are held there unless otherwise stated. Particulars for this column should reach the Editor not later than Monday morning in the week preceding the date of the meeting.

Association of Supervising Electrical Engineers, 23 Bloomsbury-square, London, W.C.1. (LANgham 5927.)
British Institution of Radio Engineers, 9 Bedford-square, London, W.C.1. (MUSeum 1901.)
Chemical Society, Burlington House, Piccadilly, London, W.1. (REGent 0675.)
Incorporated Plant Engineers, 48 Drury-lane, Solihull, Birmingham. (Solihull 3021.)
Institute of British Foundrymen, St. John Street Chambers, Deansgate, Manchester, 3. (Blackfriars 6178.)
Institute of Fuel, 18 Devonshire-street, London, W.1. (LANgham 7124.)
Institute of Metals, 4 Grosvenor-gardens, London, S.W.1. (SLOane 6233.)
Institute of Road Transport Engineers, 69 Victoria-street, London, S.W.1. (ABBey 6248.)
Institute of Welding, 2 Buckingham Palace-gardens, London, S.W.1. (SLOane 9851.)
Institution of Civil Engineers, Great George-street, London, S.W.1. (WHitehall 4577.)
Institution of Electrical Engineers, Savoy-place, Victoria-embankment, London, W.C.2. (TEMple Bar 7676.)
Institution of Engineering Designers, 38 Portland-place, London, W.1. (LANgham 8847.)
Institution of Engineering Inspection, 28 Victoria-street, London, S.W.1. (ABBey 3794.)
Institution of Mechanical Engineers, 1 Birdcage-walk, St. James's Park, London, S.W.1. (WHitehall 7476.)
Institution of Production Engineers, 10 Chesterfield-street, London, W.1. (GROsvenor 5254.)
Institution of the Rubber Industry, 12 Whitehall, London, S.W.1. (WHitehall 5012.)
Institution of Structural Engineers, 11 Upper Belgrave-street, London, S.W.1. (SLOane 7128.)
Junior Institution of Engineers, Pepys House, 14 Rochester-row, London, S.W.1. (VICtoria 0786.)
Royal Aeronautical Society, 4 Hamilton-place, London, W.1. (GROsvenor 3515.)
Royal Society of Arts, John Adam-street, Adelphi, London, W.C.2. (TRAfalgar 2366.)
Sheffield Metallurgical Association, 15 Crescent-road, Sheffield, 7. (Sheffield 53674.)